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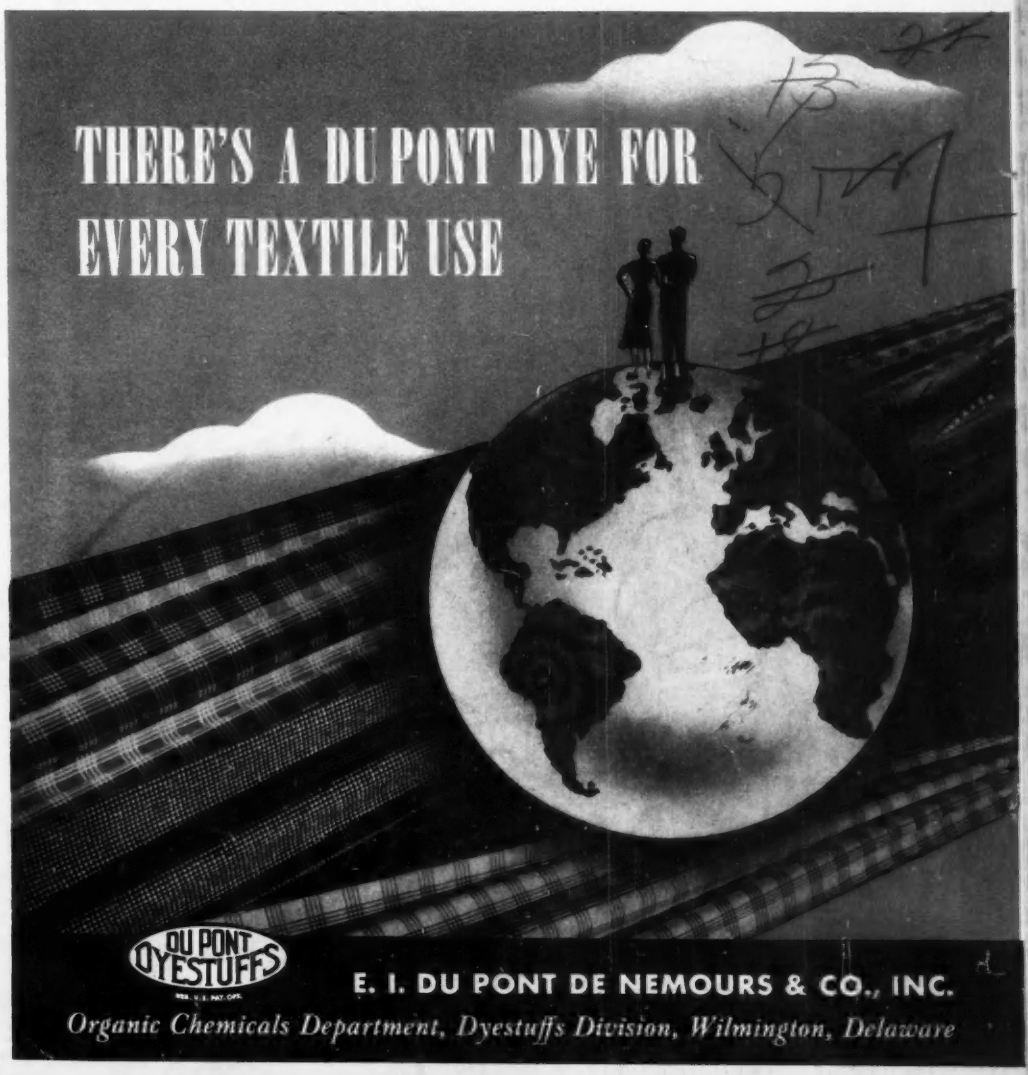
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Research Reports Number

AMERICAN DYESTUFF REPORTER

A. P. HOWES
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Official Publication of the Proceedings of the American Association of Textile Chemists and Colorists.

FEBRUARY 6, 1939
VOLUME 28 NUMBER 3

American Dyestuff Reporter, Vol. 28, No. 3, February 6, 1939 Published every other Monday
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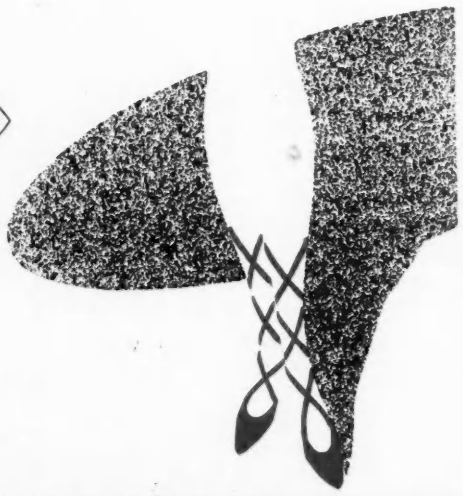

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The Research Program of

The Textile Foundation

at the National Bureau of Standards*

MILTON HARRIS**

AT the last annual meeting of this society in Philadelphia, I had the opportunity to give a talk entitled "What Can the Mill Man Expect from Fundamental Research." In that talk it was emphasized that a wealth of scientific data were already available and that there was also an ample supply of scientific investigators who were constantly furnishing new data in all fields of research. I felt, however, that there was lacking in the textile industry an organized group who could take this data, assimilate and evaluate it, and finally who could translate it into the language of the mill man. It was the hope of many of us who were interested in textile research that some day there would be such a group. At that time, I little realized that the formation of such an organization was imminent.

As many of you already know, the Textile Foundation started to support research about seven years ago, by providing funds for research fellows in various universities and also funds to the American Association of Textile Chemists and Colorists. I had the privilege of being one of the research associates of this association at the National Bureau of Standards. A large part of the original Textile Foundation program has now been discontinued with the exception of special problems at several universities. The bulk of the work, however, is being concentrated at the Bureau of Standards under what is known as the Textile Foundation Research Associateship.

At the present time, there are twelve people on the staff and in this group are included organic, physical, and analytical chemists, and a microscopist. As the work progresses several more people are to be taken on. It was purpose in choosing this staff to overcome some of the difficulties which many of us have encountered in previous textile investigations. Heretofore textile research has been carried on by individuals or small, specialized groups, who, no doubt, excelled in specific types of scientific investigations. Because of such specialization, however, many pertinent facts were overlooked. For example, many investigations relating to the physical properties of fibers were carried out from the standpoint that the materials were inert substances and the fact that they were biological substances was practically completely ignored. Many of our finest investigations of the organic chemical properties of fibers, on the other hand, have completely overlooked the fact that fibers had special structures whose architecture had a profound effect on the chemistry of the materials. We feel that the present staff, which consists of a group of investigators of very diversified training, is such that the above difficulty is automatically eliminated.

In order to give you a picture of our research program, I should like to present a brief outline of some of the work now in progress and of the general type of investigations which we expect to conduct for the next few years. In general it may be said that the work is divided into two broad classes, namely, protein fiber investigations dealing with silk and wool, and cellulose fiber investigations dealing with cotton, and cellulose derivatives. While the organic approach to these problems is somewhat different because of the inherent nature of materials, the physical and physical-chemical approach is quite similar and in most cases the same general methods of attack are being used.

One of our principal methods of attack in studying the structure of fibers is to treat the fibers in such a manner as to break them down into the largest possible aggregates and to study the nature of this breakdown. For example, wool fibers are built of spindle shaped cells about four to seven microns in thickness, and approximately 100 microns in length. Whenever wool is degraded by mechanical, bacterial and some types of chemical damage, it will be found by observing the fiber under the microscope, that the fiber is being split longitudinally into these apparently stable cells. The nature of the forces which bind these cells together and the effect of various treatments on these forces is of utmost importance in preserving the structure of the fiber. Such a problem, however, is not a simple one and involves a knowledge of biological structures as well as a knowledge of such complex materials as proteins. It is only by the realization that the wool fiber is a complex biological material that much progress in the elucidation of its physical and chemical properties will be made.

In a large number of investigations which were carried out at the National Bureau of Standards by this Association, it was shown that one of the most important chemical groups in wool was the disulfide linkage of the cystine

*Presented at Annual Meeting, Atlanta, Georgia, December 2, 1938.

**Director of Research of the Textile Foundation Research Associateship at the National Bureau of Standards.

and that on the state of this group depended to a large extent the stability of the fiber. That work is now being extended to include a study of the effect of reducing agents on wool for the purpose of furthering our knowledge of the relation of this group to the structure of the fiber.

In our cellulose fiber researches, similar investigations are under way. Cellulose fibers appear to be more or less intimate association of cellulose with other constituents generally referred to as encrusting substances. In the case of cotton these extraneous materials appear to be in part polyuronides or pectins. The purpose of the investigations in progress is to separate the cellulose from those substances under conditions which involve a minimum of degradation to either and to study the properties of the fractions thus obtained.

A simultaneous investigation of the effect of oxidizing agents on cellulose is in progress. Cellulose fibers consist of β-glucose units joined together in long chains through oxygen uniting C_1 in one unit to C_4 in another. It appears that four different types of oxidation of these chains are possible; namely, oxidation of the aldehyde groups to produce carboxyl groups, oxidation of primary alcohol groups to carboxyl groups, oxidation of secondary alcohol groups to ketone groups, and oxidation of glycol groups to carboxyl groups. Since different groups are affected by different oxidizing agents, and since the ultimate properties of the fiber depend on which groups have been altered, such an investigation may enable us to predict, for example, the relative merits of different reagents in bleaching processes.

One of our most important physical-chemical investigations deals with a study of the acidic and basic properties of silk, wool and cellulosic fibers. Silk and wool are principally composed of protein substances possessing divers chemical groups such as carboxyl, amino, imido, phenyl-hydroxyl, and guanidyl which may combine with acids and bases. Cellulose is a carbohydrate whose reactive chemical groups consist principally of the hydroxyl groups of its glucose units. The stage of combination of these polar groups is intimately related to the ability of the fibers to absorb moisture and dyes, to their elastic and tensile properties, and to their ability to withstand deterioration. The existing data on the state of combination of these groups is incomplete and to a certain extent inconclusive and contradictory. As a result, this investigation was started for the purpose of measuring the combination of the fibers before and after a variety of pre-treatments with acids and bases under conditions which permit the attainment of equilibrium before the onset of any considerable decomposition. The resulting data will be related to the variations in swelling and tensile properties which occur in the fiber over the same range of conditions.

Along with this investigation, new methods for measuring swelling of fibers are being developed. Since swelling plays such an important part in silk soaking, and in all scouring, bleaching, dyeing, and finishing processes, the importance of this investigation can not be overemphasized.

Because of the complex chemical and physical structure of textile fibers, it is necessary to approach the problems from as many angles as possible. One technique which we are now using is that of the measurement of the electrophoretic properties of fibers. The method, which consists of measuring the mobility of particles suspended in a known medium under a known external potential, measures the net charge on such a particle. The technique has been applied with considerable success in studies of inorganic colloidal materials and of many biological substances such as blood cells, bacteria enzymes, etc. Strictly speaking it is a study of surface chemistry and surface properties and is being used in our work to measure the purity and uniformity of a given material.

All of us know of the general degradative effects of light on textile materials but little is known of the mechanism of degradation and the factors which either accelerate or inhibit such break down. In one of the early projects of the A.A.T.C.C., it was shown that the photochemical decomposition of silk was greatly accelerated by acids and considerably inhibited by alkalies. In the case of wool, a similar effect was noted in spite of the fact that wool is very much more sensitive to alkalies than to acids. The latter study is being carried further and we have recently been able to demonstrate that the primary attack of light is also at the disulfide group in the fiber. These investigations are being continued and will be extended to the various fibers.

While the descriptions which have been given are necessarily very brief, it is my desire in presenting this material to make known to you the work of the Textile Foundation now in progress at the National Bureau of Standards. This, I feel is of great importance, since it is intended that the results of these researches will form a background for the solution of many of the problems in practical textile processing.

New Uses for Cotton

*A Proposed Research Program**

A. R. MACORMAC, Ph.D.**

IN the last twenty or thirty years many kings and kingdoms have had a precarious existence and a decidedly uncertain future. King Cotton has been no exception to this rule. Each year for the past five or six years, the cotton surplus and carryover have been increasing in spite of attempts to control and limit production. We believe it may be safely stated that the solution of the cotton problem will not be found in price control, government subsidy, limited production or any other such program involving an attempt to control economic forces by man-made rules and regulations, regardless of whether such rules are enforced by government regulations or by monopolistic private enterprise. Such measures are economically unsound and should be invoked only in an emergency. Even then they are of doubtful utility. History gives us numerous proofs of this. The experience of Brazil with coffee is an example.

What then is the solution of this problem? Here too we may appeal to history for the answer. If we consider the industrial history of America and attempt to analyze why certain companies and industries are more successful and prosperous than others, we find that almost without exception the outstanding successes are those which have consistently devoted considerable funds to technical and scientific research on the development of new products to meet new conditions. The automotive industry, the petroleum industry and the chemical industry are outstanding examples. Such products as Monel metal, stainless steel, Bakelite, Cellophane, and the various synthetic fibers, especially the latest development along these lines, the polypeptide synthetic fiber, Nylon, are all outstanding results of a coordinated program of research. Surely what such a program has done for other industries it can also do for cotton.

Admitting the possibilities in a program of coordinated research on cotton, the next question which arises is that of financial support. This, of course, is a very serious problem. Modern industrial research as carried on by Du Pont, General Electric, Union Carbide and Carbon Chemical Co., Corning, Pittsburgh Glass Co., and other similar organizations, indicates that the day of individual discovery and invention is past. We will still have our Henry Fords, our Wright Brothers, our Eli Whitneys and our C. M. Halls, but the hard-headed business man is much more liable to obtain satisfactory financial returns from his investments if research is carried on by a large enough group of men to give the law of average a chance to get in its deadly work. The idea that some executives have that they can hire a man with a B.S. degree for $100 to $150 per month, give him a little room in some corner of the plant, and expect within six months processes or discoveries which will cut costs or increase profits for the company to the extent of $5,000 a year is just a pipe dream. Dr. Kilpatrick of Columbia University, one of the most important contemporaneous philosophers, laid down as the fundamental basis of democracy that seemingly contradictory statement, "The whole is greater than the sum of its parts." I feel that the same thing is true of all successful research programs. Such a program should have a group of men, at least ten, who are living in pleasant and agreeable surroundings and free from financial worries. They should have ample opportunities for mutual discussions of their problems and should not be forced to consider immediate results as a necessity. Research conducted under such conditions will, experience indicates, sooner or later produce results that will give returns on the investment of a very satisfactory nature. (If half what is claimed for the new Du Pont synthetic fiber, Nylon, is true, it, like Cellophane, will be another example of what can be expected. The fundamental patents are in Carother's name but the work represents the results of more than ten years' research by a staff at times running as high as a hundred men.) Thus it is apparent that in order to insure reasonable success for a cotton research program, a considerable sum of money over a series of years must be available. Where can this money be obtained? It seems to me that there are three possible sources: (1) the growers of cotton; (2) the users of cotton, i.e., the cotton manufacturers; (3) the general public as represented by the Federal Government.

The growers of cotton have in the past been unable to do much along these lines because of lack of organization. This disadvantage has been overcome to a certain extent within the last year or so by the organization of the Cotton Research Foundation which is cooperating with Dr. Bass of the Mellon Institute in developing a research program. However, since contributions are voluntary and therefore uncertain, the future financial support is not assured and therefore unsatisfactory. As regards the second group, much of the same condition exists. If, like the automotive, steel or electric industries, the whole cotton industry had been concentrated in the hands of two

*Presented at Annual Meeting, Atlanta, Ga., December 2, 1938.
**Alabama Polytechnic Institute.

or three large concerns, we would undoubtedly have had a cotton research program well established by this time. Individual companies, especially those capitalized in the millions, have carried on quite extensive research programs. However, such programs frequently have been to the disadvantage rather than the advantage of cotton, because cotton manufacturers are primarily textile manufacturers rather than cotton manufacturers. Thus if another fiber besides cotton would give a cotton manufacturer a cheaper or a better selling product, quite naturally he would decrease his use of cotton. Anyone who is familiar with the increased use of rayon among cotton or former cotton manufacturers in the South in the last ten years, will realize that there is little real reason why this group should be called upon as the chief support of a cotton program.

There remains the third possibility—a government supported program. All modern governments concern themselves more or less with economic problems of their people and it is pretty generally acknowledged that this is proper. President Roosevelt has said that the South is economic problem number one of the nation, so that I think we are justified in feeling that the solution of the cotton problem is a concern of the national government. From another viewpoint this is also true. For the past hundred years the Federal and State Governments have spent large sums of money in agricultural research. Practically all of these funds have been spent to help the farmer produce more and better crops. The time has come when this narrow viewpoint should be changed. It has always been just as important to the farmer and the country in general to be able to dispose of his crops at a profit as it is to raise them. Under present conditions it seems fair to say that the first is the most important problem. The realization of this fact was and is the basis of the whole Farm Chemurgic movement. The time has come when the disposal of governmental funds appropriated for the betterment of the farmer should be taken out of the exclusive control of men who are merely farmers with a college education and the chemical engineer, the industrial chemist, and the business man called in to help solve the problem. Not only has business recognized this fact and supported the Farm Chemurgic movement, but the government has also done so. In all probability within a month or two after this is written a definite announcement will be made of the choice of a site somewhere in the Southeast for a regional Farm Products Research Laboratory. This laboratory will have at its disposal a sum of one million dollars per annum to be used for research on industrial uses for farm products, especially cotton. Thus we see that the question of financial support for a cotton research program is at least partially solved through the agency of the Federal Government on one hand and the Cotton Research Foundation on the other.

In reality this present attempt to outline some suggestions for a cotton research program resulted from discussions in connection with the proposed Federal Laboratory. Last Spring Dr. W. T. Schreiber, in charge of the Department of Agriculture's work on sweet potato starch at Auburn, was asked to give his ideas along these lines. Between us we talked the matter over for several weeks and then he finally submitted his report. Again, when this Autumn Auburn was preparing a brief for presentation to the Department of Agriculture, setting forth its advantages as a location for the proposed laboratory, Dr. C. A. Basore, Professor of Chemical Engineering at Auburn, Dr. Schreiber, and myself, had some more lengthy discussions. The suggestions which follow are thus the combined efforts of the three of us expressed for the most part in my own words.

Before embarking on a discussion of specific problems, it would seem well to discuss first the cotton fiber itself, second the cottonseed, and third the whole cotton plant.

In the cotton fiber we have the purest form of natural cellulose, practically all of it is present as alpha cellulose, the most valuable form of cellulose. The cotton fiber, due to its twist and the spiriality of the component crystallites, is in a condition which lends itself ideally to the drafting and spinning processes. Of course it is true that the cotton fiber also has certain disadvantages such as lack of luster as compared with rayon, silk or to a slight extent linen, shortness of staple as compared with linen, wool or silk, non felting and poor insulating ability as compared with wool. However, we hope to show that there are excellent prospects that we can overcome these disadvantages by various mechanical and chemical treatments of the cotton fiber. We feel there is an excellent prospect of successfully accomplishing these objectives because of two factors which are greatly to the advantage of cotton—its cheapness and the gross and ultimate structure of the cotton fiber. Cotton is the cheapest of all fibers. Raw cotton at present is selling for 8 cents per pound and cotton yarn of about the same size as 150 denier rayon will sell for 27 cents per pound, whereas rayon is about 62 cents per pound. The other fibers are still more expensive. Besides, as is well known, rayon has been cotton's chief and most serious competitor. Cotton is superior to rayon in many properties, the most important of which are wet and dry strength and general wearing qualities. Rayon is superior to cotton in only one real quality—a smooth surface. This gives rayon a higher luster and better nonclinging qualities. This last property is more important than may immediately appear on the surface, because it is a quality that women consider essential in slips and other undergarments. I had never realized the importance of this factor till discussing this matter with a young woman this past summer who is somewhat of an expert along these lines. It appeals to me as a very important point. Thus it appears that any means of smoothing out the surface of the cotton fiber, would open up unlimited fields in which cotton could replace rayon and silk. Likewise any means of increasing the felting and insulating

ability of cotton will make it a serious competitor of wool. We hope to show that there are good prospects of being able to do much along both these lines. In order to approach this problem logically, we must understand something of the nature of the cotton fiber itself. The cotton fiber is a single cell. It grows out of the epidermal cells of the cottonseed. These cells first grow out to their ultimate length as a very thin cell wall of cellulose enclosing a liquid interior. Thus at this stage the cotton fiber is a long thin sack filled with liquid. When the fiber has reached its full length, the liquid gradually deposits layers of cellulose on the interior of the thin sack. During this time there is a gradual drying up of the fiber so that finally we have our mature cotton fiber which consists of concentric layers of cellulose forming the body of the cotton fiber with a hollow lumen on the inside. The evaporation of the water and the deposition of the cellulose leads to a collapse of the sack to give the twisted ribbon shape of the mature cotton fiber. The concentric layers of cellulose composing the cotton fiber are in turn composed of long chains of cellobiose units which spiral around the fiber in much the same manner as the individual fibers in a cotton yarn go to make up the thread. These cellulose crystallites are embedded in a cementing material which I believe is essentially similar to cellulose itself. Mrs. Wanda K. Farr speaks of this cementing material as pectin or pectic acid and estimates that it is about 2 per cent of the total. I would prefer to consider it simply as cellulose composed of crystallites of shorter length and less regular arrangement than the main part of the fiber. Using this picture as a basis we see that the possibilities of modifying and improving various properties of the cotton fiber are enormous. By softening this cementing material to allow the crystallites to slip over each other, we may be able to increase their twist and give greater strength to cotton or increase their draft and give greater length to the cotton fiber or possibly both of the objectives might be accomplished at one and the same time. Cellulose containing no active group but the hydroxyl would naturally be a more inert material than wool or silk or other protein like compounds which contain both the amino and carboxyl groups. Likewise the valence bonds in cellulose are carbon and carbon oxygen bonds only where as in proteins we have the additional nitrogen carbon bond which can be shown by thermodynamic considerations to be less staple than the others. It may be said that these are purely theoretical considerations but to me they indicate that cellulosic fibers can be made which will be superior to protein fibers in strength and resistance to deterioration. Certainly in any comprehensive research program these factors should be considered. Thus we see that if we consider the nature of the cotton fiber and its low cost in comparison with other fibers, the prospect of industrially profitable results from research investigations on it are very promising.

When we come to a consideration of the cottonseed we find that we have a valuable raw material which is available at a relatively low cost because it is a by-product of the ginning of cotton to give lint cotton. The possibilities in its use are numerous because of its complex nature and are best considered as individual problems depending on the part of the cottonseed used. Thus we have cellulose from cotton linters, oil and proteins from the cottonseed meats and xylose furfural and similar carbohydrate degradation products from the hulls.

It is not our intention in the present paper to discuss in any great detail the possibilities of the utilization of the whole cotton plant since this subject was extensively discussed in the paper by Macormac presented before the Piedmont Section at Greensboro in March, 1937. See American Dyestuff Reporter, *26*, 389: (1937). Certain phases of this investigation are being continued under Dr. Cameron's direction at Chapel Hill with the support and cooperation of the Cotton Research Foundation and the Mellon Institute. It has been definitely shown that the oil can be extracted from the whole cotton plant and that the resulting oil-free material can be made into a high alpha cellulose pulp by the nitric acid process. The harvesting of the whole cotton plant as carried out at the Dockery plantation near Rockingham, North Carolina, would of course cut costs very greatly. Some work I did while at Chapel Hill leads me to think that it may be possible to recover lint cotton of a staple length suitable for spinning from the ground whole plant. I am also quite certain that a cellulose pulp suitable for brown paper, resin filler and similar uses, could be recovered from the whole cotton plant after the more valuable lint cotton and cottonseed oil had been separated.

Bearing in mind what has already been said, three classes of problems suggest themselves:

(1) Chemical and mechanical treatment of the cotton fiber at any stage of manufacture to modify its properties whereby it may become a more serious competitor of linen, wool, silk or rayon.

(2) Research projects to determine the best means of obtaining the greatest economic value out of the cottonseed including cotton linters, cottonseed oil, hull fiber, cottonseed meats and cottonseed bran.

(3) Research project to determine thoroughly the possibilities of the Cameron Dockery whole cotton project and the possible utilization of cotton stalks.

Specific problems along these various lines are suggested below. Many of these problems are not original but are included here for the sake of completeness. In most cases a bare statement of the problem is made without any detailed discussion. Many of the problems suggested overlap each other. In other cases several different ways of accomplishing the same object are suggested.

PROJECTS BASED ON THE COTTON FIBER

In connection with problems on the cotton fiber, there are two main objectives—first, to increase the luster so as to make cotton a competitor of silk, linen or rayon; sec-

ond, to increase its felting and insulating properties to make it a competitor of wool.

(1) Improvement in the methods of mercerization to increase the luster and strength of cotton. Study of the effects of time, temperature, use of wetting out agents and other mercerizing agents such as sulfuric acid.

(2) Use of Schweitzer's reagent or a similar compound to smooth the surface and increase the luster of cotton. The formation of Schweitzer's reagent and its special action on cotton is based on the utilization of the coordinate covalency of copper for ammonia. The equilibrium concentration of the complex covalency ion is kept rather low due to the volatile nature of the ammonia. If for ammonia a less volatile amine might be substituted it is entirely possible that much improved results would be obtained.

(3) The conversion of the outer layer of the cotton fiber to a cellulose ester or ether to increase the luster of cotton.

(4) The use of thiocyanates or other solvents for cotton to increase its luster.

(5) The softening of the cementing material (pectin of Farr) which holds the crystallites of the cotton fiber together by some solvent action and the use of tension or draft on the fiber in this condition to give increased luster, increased strength and increased elasticity by a reorientation of the crystallites so that they have a greater twist, a changed angle with the fiber axis and a more or less stretched condition.

(6) Treatment of the cotton fiber with a solvent or plasticizer which would render the whole fiber plastic and the application of tension to the fiber in this condition resulting in an increased staple length as well as increased luster. This might well be done on a machine similar to a comber.

(7) The treatment of the cotton as it comes off the card with a cementing material in a volatile solvent whereby the cotton fibers might be stuck together to give a greatly increased staple length.

(8) Plasticize the surface of the cotton fiber during spinning to give a stronger, more compact yarn.

(9) The treatment of cotton by the Lanatin or some similar process to give a fiber resembling wool. This is a patented process which probably involves the treatment with sodium hydroxide without tension. Lanatin or Lanatinized fibers should not be confused with the Italian casein product, Lanital. The Lanatin cloths on the market at present are made from jute, hemp, etc., and resemble wool in feel and appearance.

(10) Treatment of cotton with a plasticizer or resin to give increased stiffness to the fibers thus permitting its use in pile fabrics, plushes, etc., to replace wool or mohair.

(11) Treatment of napped cotton goods with a resin or other finishing compound to give material that will have the softness and warmth of wool.

(12) Development of designs and finishes on cotton to make it resemble wool as far as felting and surface appearance are concerned, so that cotton could replace wool in men's suiting and ladies' dress goods without increased warmth or insulating properties.

(13) Research on the spinning of very fine counts of cotton to give yarn of increased strength and fineness.

(14) Research on the kier boiling and bleaching of cotton with special emphasis on the use of sulfonated fatty alcohols and other detergents with the main object of increasing the absorbency of cotton to replace linen in towels, etc.

(15) Cotton cloth of net-like structure coated with a cellulose ester to replace Cellophane or similar products.

(16) Continuation and extension of the study of the use of cotton in highway construction. Investigation of the possibility of the use of raw or lint cotton to add strength and body to concrete without the necessity or expense of first making it into cloth.

(17) Production of artificial leather by coating cotton cloth with a synthetic resin.

(18) Use of synthetic resins or lacquers, together with a finely woven cotton cloth to give oil cloth without a smooth oily finish.

(19) Washable finishes on chintzes, shirtings, ginghams, etc., by use of synthetic resins or cellulose ester preparations.

(20) Improvement of the wearing qualities of cotton cloth by use of permanent finishes.

(21) Cellophane reinforced with cotton cloth of net-like construction to prevent tearing and cracking.

(22) The use of para sulfonal chloride or similar compounds to change the dyeing and finishing properties of cotton cloth, thus giving patterns and designs by a printing process which is cheaper than weaving. The resulting product is sometimes called "immunized" cotton.

(23) The use of some solvent or aqueous solution in the spinning of cotton yarn to increase the twist, fineness and strength of the resulting yarn.

(24) The use of loose cotton as a resin filler to decrease brittleness and increase strength.

(25) The incorporation of small amounts of dyed loose cotton in Cellophane to give novelty effects. Would also increase tearing strength.

(26) Use of loose cotton as a binder in rubber articles—tires, shoe soles, etc.

(27) Finishing cotton with a slight napping to give softness, increase weight and give a dull soft tone.

(28) Finishing cotton with a cellulose ester solution or resin containing a delustering pigment to give a dull soft luster and still have a non-clinging garment suitable for slips and women's underwear in general.

(29) Use of fine count highly mercerized cotton yarn for ladies' sheer hose.

PROJECTS BASED ON COTTONSEED PRODUCTS

(30) Application of modern engineering principles to

cotton ginning machinery with the hope of increasing the yield and quality and decreasing the cost.

(31) The use of cottonseed protein or cottonseed meal in the making of plastics and the use of cotton linters as a filler in plastics.

(32) Use of cotton linters as a source of alpha-cellulose. Cotton linters is at present our best and purest source of alpha cellulose but it has lost ground in competition with wood pulp which has been much improved to meet the demand of the rayon industry for a high grade alpha cellulose pulp. The conversion of cotton linter into alpha cellulose is a cheaper and simpler process than that used for wood resulting in less degradation and loss. The decreased use of cotton linters in the manufacture of rayon has been to some extent due to the fact that the supply of cotton linters has not been uniform and dependable. By proper control and sales methods much of this business could be recovered.

(33) Use of cotton linters in place of loose cotton in several previously suggested uses such as felts, suitcases, mats, for reinforcing rubber, etc.

(34) Increased cottonseed oil production by use of solvent extraction methods. By present methods about 10 per cent of the oil is left in the cake.

(35) Sulfonation of cottonseed oil to replace sulfonated castor, olive or other soluble oils.

(36) Conversion of cottonseed oil into amides, alcohols and other derivatives useful as detergents, wetting agents, etc.

(37) Recovery of xylose from cottonseed hulls.

(38) Development of new uses for xylose and its compounds. It is an excellent non-fattening sweetening agent and a reducing agent.

(39) Production of furfural from xylose and the development of new uses for furfural and its derivatives. This is an aldehyde and thus has many of the possibilities of other aldehydes.

(40) Plastics may also be made from xylose and furfural.

(41) Use of furfural as a dye intermediate.

(42) The production of food products from cottonseed meal similar to peanut products now on the market.

(43) A study of the action of enzymes or ferments on cottonseed meal.

(44) A study of the action of enzymes on cellulose as a possible means of controlled degradation of cellulose. It is well known that termites are capable of using cellulose as a food, hence their digestive system must contain an enzyme which will degrade cellulose.

PROJECTS BASED ON THE WHOLE COTTON PLANT

(45) Further investigation of the suggestion made by Macormac (see American Dyestuff Reporter *26,* 389) of grinding the whole cotton plant extracting the oil and separating the oil-free residue into lint cotton and stalks, etc. The stalks, etc., can then be made into a cellulose pulp suitable for use in brown paper or as a filler. The lint cotton may have possibilities as a fiber.

(46) Making of cellulose pulp from the oil-free whole cotton plant. This would give a cheap pulp that might find many uses.

(47) Further investigations of the nitric acid method of pulping the whole cotton plant or other similar vegetable material. One of the authors has shown that this method gives a high grade alpha cellulose pulp from the whole cotton plant. The equipment and chemicals required make this process considerably cheaper than the methods used for wood.

(48) A study of the suitability of the whole cotton plant for destructive distillation and the recovery of wood alcohol, acetic acid, charcoal, etc. It has been demonstrated that corn cobs are superior to wood for this purpose and the same may be true of cotton stalks or the whole plant.

(49) A study of the conversion of cotton stalks or the whole plant into paper.

(50) Mixing cellulose pulp from cotton stalks or the whole plant with cement, silica gel, etc., to give fireproof shingles, wall board, beaver board, etc.

(51) Cellulose pulp plus plaster of paris or similar material to give building blocks and insulating material for use in the building industry.

(52) Use of the whole cotton plant or cotton stalks to make a product similar to plastic wood.

(53) Use of the whole cotton plant to make fillers for resins, etc.

(54) Use of whole cotton plant as a source of oxalic acid or other organic chemicals.

(55) Use of whole cotton plant as a source of absorbent carbon.

In conclusion the authors maintain that King Cotton must get rid of his inferiority complex. They do not agree with those who contend that the economic position of cotton is necessarily hopeless but on the contrary take the position that much could be done to stabilize and maintain cotton prices by a comprehensive and intensive research program along the general lines indicated. Emphasis should however be put on project leading to the use of cotton in high grade and expensive material rather than cheaper class of goods as has been done to some extent in the past. One of the most encouraging features of this problem is that cotton is the cheapest of all fibers and thus gives the research worker the opportunity to use relatively expensive processing and finishing procedures and still compete on a price basis with the other fibers. All signs point to an increased interest on the part of both public and private interests in this country in research on projects aiming to increase the industrial consumption of agricultural products. If the suggestions made in this paper serve as an additional incentive to attempt such work on cotton or its products, we will feel that our efforts have been well worth while.

Three Elements Affecting the

Accuracy of Testing Textile Fabrics

Human, Mechanical and Atmospheric Conditions

R. H. ADAMS**

HUMAN

THE constant increase in the use of fabrics for mechanical purposes, and the substitution of heavy cotton duck for many other engineering materials, such as leather, steel and rubber, have brought into prominence the testing of textiles during the last twenty years to an increasing degree. Many yarns and heavy cotton fabrics and ducks are now purchased upon just as accurate specifications for strength as would be the case with iron and steel. Simultaneously there has naturally arisen a demand for better equipped laboratories and a more thoroughly trained personnel and a greater requirement for more accurate testing of these fabrics, thereby removing one unnecessary source of friction between the consumer and the source of supply. It is with this aspect that I am concerned in this paper.

For a long time the testing of textiles has had but little scientific value inasmuch as it was carried out in a haphazard fashion with but little regard to the actual condition of the fabric and with very great errors in the preparation of the samples and in making the strength determination in the testing machines. About this time it was discovered that if textile tests were to be considered of importance they must be carried out under the supervision of a more thoroughly trained textile laboratory personnel to remove the inaccuracy of the human element—one who has had enough practical experience to remove the errors and loss in inaccurate mechanical measurements in making preparation of specimens for testing and setting up of machines for physical testing; one who knows they must be carried out under very exact atmospheric conditions.

After we have designed and set up our laboratory, equipped with conditioning apparatus for a standard condition of 65 per cent relative humidity and 70 degrees temperature, and with complete equipment for physical testing and instruments for all analytical work, with all equipment properly placed as to height and convenience, we must have a thoroughly technically trained laboratory expert, preferably one with some practical mill experience, to become directly responsible for the three elements under discussion. It is here that we begin to measure our raw materials to get at the basic qualities for spinning yarns that must go into highly specialized fabrics.

The chief of the testing laboratory must plan his routine work very thoroughly, for it is here that the mill or group of mills must depend on the accuracy of the personnel of the laboratory. The operator in a textile laboratory should above all things have a definite and scientific program in view when he undertakes the determination of the physical qualities of textile materials.

Samples which are sent to the laboratory are usually checked and assorted for quality and grouped according to specifications and requirement of the materials and the customer's requirements as to specification. It is then that the samples are placed for a proper conditioning period and all specials are assigned to the more experienced operator, since he is a specialist for this particular line of material. In doing this the operator knows just what the customer requires; the size of specimens, the distance between jaws, the proper weight, the tensile required, twist, gauge and unit size.

It is very important that the chief operator keep constant check on the materials going through the laboratory to see that the type and right capacity of machine are being used for the various weights and unit size. If he finds considerable variation occurs in the tensile and weight he immediately has construction and unit size checked, and quality of material. If he finds the tensile continues on the low side he will immediately call for additional samples from current production. In the meantime he checks his machines for distance used between jaws and the specimen size against customer's specifications.

MECHANICAL

All physical testing machines are strongly built and usually very rugged. Most of the lighter instruments in use are built to precision, but due to the following reasons errors in tensile strength and elongation are caused: defective ball bearings and failure to keep the bearings cleaned and oiled. All bearings that are constantly used should be removed every 90 days, cleaned thoroughly with gasoline and repacked with a good lubricating grease on the main axis. The friction of all slides, guides, and carriages should be reduced to a minimum by correct alignment and proper lubrication. The upkeep of the machines in the laboratory should be well attended to and adjustments of stretch apparatus, dials, etc., should be carefully performed. The jaws of fabric testing machines become worn by constant pressure of the upper jaws on the lower

*Presented at Annual Meeting, Atlanta, Ga., December 2, 1938.
**Callaway Mills.

anvils. Any good mechanic can correct this by the use of a piece of folded carbon paper and a sheet of writing paper also folded to make a slight impression between the jaws. If the jaws are kept smooth this will reduce the slippage of the specimens when the load is being applied by the pulling jaws.

The main pulling screw, if allowed to become worn in the brass bushing, will cause an unusual amount of lag in making elongation charts for records of stretch and cause errors in reading the stretch diagram.

To avoid vibration it is very important in installing vertical testing machines to place them on I beams placed in a rich mixture of concrete 18 x 18". If on a ground floor this will reduce friction caused by vibration when machines are not level. The same thing is true of the horizontal machines. If they are placed on studs in concrete and on adjustable nuts, the machines can be easily adjusted and leveled and at the same time allow all movable parts to work more freely.

It is possible for the main journal to slip causing the bearing to slide with the journal and affecting the freedom of the pendulum as it swings into position when load is being applied. This will create an unusual amount of friction by allowing one side of the pendulum to swing against the side of the head piece.

A regular procedure for maintenance and upkeep of testing machines in a laboratory is very important. A weekly cleaning and inspection should be made of all equipment. A check for sensitivity should be made as often as necessary. Section 18-d-179 (A.S.T.M. Designation) is a good method to follow, i.e., dead weight method. Section 20-d-179 is a very thorough and practical method to be used for both vertical and horizontal machines. Soft drawn copper wire ranging in number from 4-6-8-10-12-14-16-18-20-22-28 can be successfully used on the heavy machines to as low as 5 lbs. On the lighter machines the wire can be kept on rolls in the laboratory at all times and be cut and used as needed. When an inter-laboratory check is necessary a certain number of pieces can be cut for this purpose and easily distributed to any number of laboratories for check purposes.

ATMOSPHERIC CONDITIONS

The increasing use of textile testing and manufacturing to specification makes imperative an understanding of the importance of the standard atmospheric conditions and its influence upon cotton textiles. Certainly in our day when the tremendous speed of style and merchandise movements necessitates coordinated action in every industry in the country, nothing is more important than standard atmospheric conditions in the manufacture and testing of textile materials. Often the external atmospheric conditions are fluctuating rapidly, swinging from one extreme to another in temperature. Continued rainfall or dry windy days will exert influence upon our materials in process which must be corrected by scientifically created and controlled atmospheric conditions.

It will readily be seen that the variety of finished products involved in manufacturing operations necessitates the closest observation and checking of each process with regard to tensile strength, stretch, elasticity, durability, weight, construction, and the physical properties in general. There is every reason to believe that any product can be made better by the use of a thoroughly equipped air-conditioned laboratory. It would be justified even if its only achievement was the day-by-day maintenance of uniform quality. This has become increasingly apparent to those directly responsible for tests that must be accurate.

Even the sensitive instruments are not to be relied upon unless free from fluctuations of temperature and air drafts. It is evident, therefore, that an ideal laboratory with a complete control unit is necessary in accurate laboratory work, not only to secure a known degree of moisture in the material and to assure uniformity throughout the entire specimen, but also to maintain the reliability of the testing equipment itself.

Air movements in conditioning textile materials are very important. The condition of textile samples can be made to change with the atmospheric condition more thoroughly and more rapidly by spacing properly in rotating conditioning racks of proper speed and height. Heavily plied yarns and heavy fabrics should be so arranged as to meet movements of air as it is discharged from the air ducts against the wall and as the air is being returned to the air washer. This will help the samples to absorb or release moisture and to bring them into thorough equilibrium with the surrounding atmosphere and speed up conditioning and penetration. Any attempt to condition yarns or fabrics in a careless or hasty manner is time lost, and from my experience in testing textile materials I would have no faith in any breaking strength or weight test in which the regain of the sample being tested was not given. It is, therefore, very necessary that samples remain in conditioning racks until each group has had sufficient time to reach its full equilibrium each time before testing.

The factors affecting the strength, stretch, twist and the diameter of the yarns, both single and plied, should be thoroughly studied to obtain a clear conception of the cause of different results found in physical testing. It is highly important to know these facts before the yarns are plied and woven into fabrics which call for special treatment. This cannot be done unless they are conditioned each time the same length of time and under the same conditions.

Samples coming to the laboratory from different mills and in some instances from quite a distance from each other will be quite different in the moisture content and for this reason no samples of yarns on bobbins or samples of fabrics should be stacked on tables. They should be hung up and properly spaced, and bobbins or spools of yarn should be set up on end in racks provided for this purpose where they can have plenty of air space between them for proper circulation of air.

In considering the three elements above from the standpoint of the producer and consumer as well as commercial laboratories, we are faced with these facts. We find that we have in use in this country three distinct types of laboratories, and in order to identify the three important elements which we are discussing we must classify them as follows: Class A., B., C.

We find that class A is thoroughly equipped with the best of standard equipment, with temperature and atmospheric conditions under complete control. They have plenty of room and are scientifically lighted. Machines are placed in a convenient location and at the proper height. Everything is conveniently arranged as to time and labor saving. The personnel is thoroughly trained and the daily routine testing program is thoroughly planned. Each item of material is conditioned according to the required number of hours as to the unit size and its texture. Yarns, fabrics and ducks are tested according to specification and each classified as to the period required for conditioning before testing. Reports are kept according to the type of material and specification requirements of customers. Daily records are kept of all tests made and a monthly, quarterly, semi-annual and yearly average of tests are kept.

Class B laboratory has the necessary testing equipment and in many instances they have experienced operators. They have some method of humidifying the room, but no method of controlling the temperature or humidity. Both the humidity and temperature are subject to wide variation in results obtained in testing under this condition, due to variation in regain.

Class C laboratory has the necessary physical testing equipment and in some instances an experienced operator, but no method of humidifying the room or temperature control. Under these conditions tests are subject to a very wide variation and such conditions are very unsatisfactory for setting up a standard for material control. Since it is placed at the mercy of any variation in any change of outside weather and fluctuating with conditions which may be swinging from one extreme to another, it is physically impossible to check with a Class A laboratory as a difference of 10 to 22 per cent is usually found in the two tests. It has taken time and education to show that in the broadest sense the best interest of producer and consumer of material are not conflicting, and that every step that has been made toward the elimination of the three elements which cause inaccuracy in the testing of textile material, and the establishing of standard methods and standard conditions are of mutual advantage.

The standardization work of the American Society for Testing Materials and the American Association of Textile Chemists and Colorists, and other societies since their organization, is now, as a result of many years' experience, upon a stable and enduring foundation and will fairly accurately reflect the present day status in this country of developments and use of standard specification and methods of test for textile materials for the greatest degree of accuracy.

Procedure for

Testing the Wettability

and Rate of Evaporation of Fabrics*

F. M. PESCHEL

THIS test was devised to determine what the differences in the rate of absorption and evaporation from various types of treated and untreated fabrics might be when in contact with the human body under conditions of excessive perspiration. The loss in moisture through evaporation from the surface of a fabric, which is continuously supplied throughout the test with replacement moisture, is tabulated at observed intervals.

Apparatus: (Fig. 1.)

1. A Thwing-Albert Vapometer cup.
2. A small cylinder with an inside diameter of 1″ and and a height of 1¾″ made of aluminum .0014″ thick; its seams crimped in such a manner that the inside surface of the cylinder is unbroken and smooth. (Fig. 2.)
3. Strips of blotting paper 3.1″ in length, 2-1/16″ in height, and .030″ ± .001″ thick.
4. A chainomatic balance with fractional weights regulated from the exterior of the balance case so that the balance case door may remain closed as much as possible.

*Apparatus and Test Procedure developed by United States Testing Co., Inc.

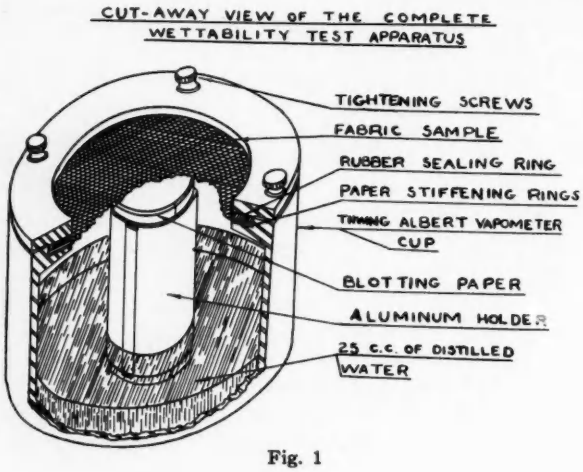

Fig. 1

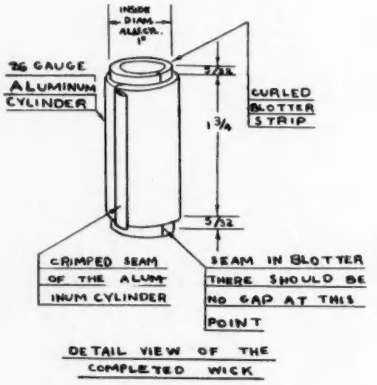
INSIDE DIAM. ALUM. CYL. 1"
26 GAUGE ALUMINUM CYLINDER
5/32
CURLED BLOTTER STRIP
1 3/4
5/32
CRIMPED SEAM OF THE ALUMINUM CYLINDER
SEAM IN BLOTTER THERE SHOULD BE NO GAP AT THIS POINT
DETAIL VIEW OF THE COMPLETED WICK

Fig. 2

5. The entire procedure of the test should take place in a room of constant temperature and humidity.
6. A stop watch.

PROCEDURE

Curl a strip of blotting paper over a ¾" rod, taking care not to crease it, and shape it to the inside of the aluminum cylinder forming a continuous wick extending 5/32" above and below the metal cylinder. There should be no pronounced break at the seam in the blotting paper.

A circular test section, 3" in diameter is cut from the fabric to be tested. This sample should fit the mouth of the Thwing-Albert Vapometer snugly.

Some fabrics will be found to have insufficient rigidity or stiffness to be placed in the mouth of the cup. In such a case stiffening rings of bond paper are cut having an outside diameter of 3" and an inside diameter of 2½". One of these stiffening rings is placed above and another below the test specimen of fabric and fastened in place with a good grade of library paste. (Fig. 3). All samples are hung in a constant humidity room for a period of three hours before the sample is subjected to test. In cases where the samples require stiffening rings

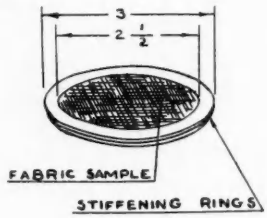

Fig. 3

of bond paper, they should be allowed to stand over-night so that the library paste may dry out completely.

To begin the actual test 25 cc. of distilled water is placed in the Vapometer cup; the wick is then placed upright in the center of the cup. At the moment moisture is noticed in the wick above the aluminum collar, the fabric sample is placed over the mouth of the cup and the top is tightly clamped in place. The entire set-up is then placed upon the balance pan and a weight is obtained as rapidly as possible; this weight will be the original weight. The door of the balance is then closed and kept closed as much as possible since the open balance door will allow currents of air to pass over the sample causing variations in evaporation loss and consequent inaccuracies in the test results. The stop watch is started as soon as the original weight is secured. Weighings are then made in as rapid succession as possible, the time of each weighing being recorded. After ten minutes have elapsed the weighings may be made at less frequent intervals. The weighings are continued for a period of 30 minutes.

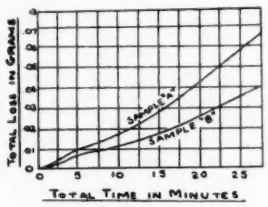

Fig. 4

To compare two samples the results are plotted in graph form, plotting the evaporation loss in grams against the time in minutes. See Figure 4. All test fabrics should be run in triplicate.

American Dyestuff Reporter 28 #3 Feb-6, 1939.

Proceedings of the American Association of Textile Chemists and Colorists

Flax

*Its Agricultural and Industrial Possibilities**

C. G. WORTHINGTON† and C. A. JONES**

FLAX was the principal fiber crop of Colonial America, and was grown and processed successfully in all thirteen of the colonies. It was still grown extensively as late as 1850. There are a surprising number of the older country people who remember working in the flax fields and helping with the tedious and unpleasant job of retting and scutching the straw. Fiber flax production collapsed in this country with the advent of cheap cotton, made possible by the cotton gin, and with the rapid improvement in cotton spinning methods that followed.

Today the only commercial production of any consequence is in Oregon. Even here only about $200,000.00 worth of fiber is processed annually. Europe has for many years been the chief fiber flax producing area of the world. It exports to this country annually from thirty to one hundred million dollars worth of fiber and linen goods.

Besides its use in fabrics, nets and fish lines, thread, twine, etc., flax also finds its way into fine papers—such as cigarette, bond and currency paper—where its ability to impart flexibility and tear resistance, and its freedom from odor on burning makes it a superior raw material. The paper mills use it in the form of old linen rags and new cuttings which are largely imported from Europe. Sorting and cleaning the rags is a laborious, disagreeable job, and considerable waste results. Of late years the supply has tended to decrease and to become uncertain. Some manufacturers of cigarette paper, which is now made almost entirely in France, are today actively investigating the possibility of utilizing home grown flax fiber. About four million dollars worth of cigarette paper alone is consumed every year by the American public.

As the production of flax for fiber died out in this country, its growth for seed began to be important. The plant was found to be ideal as a breaking crop for the new land beng opened up in the Northwest—particularly in the Dakotas and Minnesota. Today it is one of the most important crops of that region and is grown there for its seed, from which linseed oil is crushed in nearby manufacturing centers. The importance of the industry may be judged from the value of its products—oil, cake and meal—which totals well over one hundred million dollars per year. Only about half the annual requirements of the industry for seed are, however, grown here, the balance being imported, chiefly from the Argentine.

These tremendous importations of seed, fabric and fiber, coupled with the threat of war in Europe that might cut off our present supplies, seems to justify the expansion of flax production in this country. Our interest down here, is primarily in its possibilities for the South. These possibilities seem to us to be as follows:

First, of contributing to the agricultural readjustment of the region. The poor returns from cotton production have turned farmers to consideration of other crops that will yield greater returns and, at the same time, provide diversification and build back the fertility of the soil. Flax is a quick cash crop, and seems to net greater returns than corn or cotton; is no harder on the land than other grains, particularly if followed by a grass or legume crop; and contributes to soil erosion control, as it is not a cultivated crop. Neither is flax affected by the boll weevil and other common crop pests.

If we are going to grow flax we must also provide means of processing and utilizing it here so as to obtain the maximum benefits for the region from its manufacture into consumer goods. Flax processing plants are

INTRODUCTION

There are two types of flax, one grown for seed and the other for fiber, but they are much alike in appearance. The plant is slender, averaging about thirty inches in length, with a short tap root and with branching tops that terminate in seed bolls. The fiber of value lies in bundles around the outside of the stem, and extends from just above the root to the first branches.

Flax is grown and harvested much like wheat and oats. Seed flax can be raised over a wide range of soil and climatic conditions but is grown chiefly in regions where the moisture is insufficient for fiber flax. As the plant is grown for oil purposes, the seed are allowed to mature before the crop is harvested. At this time the fiber is coarse, harsh and weak, not well suited to textile use. It is the general practice of farmers to dispose of the straw by burning.

Fiber flax is more sensitive to climate. It requires coolness and moisture during the growing season, followed by a warm, dry period for maturing and harvesting. In a dry climate the plant is short and woody and yields a harsh, dry fiber. The usual practice is to harvest the plant when the seed are about two-thirds ripe, as the best quality of fiber is then obtained. Under this procedure the seed ripen in storage and are sold to linseed oil mills for crushing.

*Presented before Annual Meeting, December 3, 1938, Atlanta, Georgia.

**Director, A. French Textile School, Georgia School of Technology, Atlanta, Ga.

†T.V.A. Research Fellow, State Engineering Experiment Station, Georgia School of Technology, Atlanta, Georgia.

well suited to small community industries and would contribute needed credits to the unbalanced economy of many rural regions.

Perhaps the greatest industrial possibilities for flax lie in its use by the cotton textile mills. The demand for new and better fabrics is pressing and the mills are turning more and more to the blending of fibers to meet this demand. Cotton and rayon, cotton and wool, and more recently imported flax with cotton and with rayon are some of the combinations now in commercial production. Domestic flax when properly processed is believed to be as well suited as the imported product for blending with other fibers. It may be that the mixture of other fibers with cotton will actually stimulate its greater consumption, as well as provide work for idle cotton spindles and labor.

Much of the flax fiber that is unsuitable for textile use would be a satisfactory raw material for paper. While the fine paper industry has yet to develop in this region, there are signs of a trend in that direction. One of the largest manufacturers of cigarette paper in the world is now building a plant in Western North Carolina which, it is reported, will use domestic flax fiber as well as linen rags and cuttings as their source of raw material.

Another enterprise that would be aided by flax production in the South is the cotton oil industry. These mills operate for only a few months of the year, while their overhead expenses go on throughout the year. If they had flax seed to process in addition to cottonseed their season of operations would be extended, their unit costs reduced, and their profits increased. This has been the experience of cotton oil mills in the flax and cotton region of California. Some mills in Georgia are already profiting by processing peanuts as well as cottonseed. Incidentally, linseed meal, when mixed with cottonseed meal, makes an excellent cattle food.

There are yet unexplored industrial possibilities in the by-products from flax processing. Close to 50 per cent of the flax plant is the woody core of its stem. This is ordinarily broken up and wasted when the fiber and seed are extracted, yet it contains some cellulose as well as protein and fat. There is good reason to believe that this woody waste or shive would be suitable (1) as a filler material for plastics, (2) as a source of furfural, a chemical that is beginning to have wide use in industry and (3) as roughage in cattle food.

About four years ago the Tennessee Valley Authority became interested in the possibilities of flax for the South. The problem was studied carefully, and it was decided that investigation of the adaptability of flax to southern agriculture and utilization of the fiber by the cotton textile industry would be of most immediate value. A large acreage of flax was produced near Knoxville, Tenn., and converted into fiber by both established and new processing methods. The results from this program clarified the problem greatly, and indicated the lines along which further work should be done. The co-operation of the Georgia Agricultural and Engineering Experiment Stations was therefore obtained, and for the past two years an extensive research program has been carried on by these stations, working together.

Flax was at one time grown in Georgia but little is known of its adaptability to present day agriculture. The program of the Agricultural Experiment Station is therefore particularly directed toward determining the regions best suited to growing it, the best agronomic practices to follow and the economic factors involved. Several more seasons of operation will be necessary to establish these facts, but the results to date indicate that flax can be grown successfully in certain parts of the state. As Director Stuckey puts it, "If the Georgia farmer can make a better living growing flax than cotton or some other crop, he will do so." He emphasizes however that, while flax need not yield as much here as in Oregon or other high yield areas to be attractive to the farmer, he must be assured of a fair return on the venture. This is an important point, for so often the farmer receives a too small share of the value of industrial goods processed from agricultural products.

The subject of the Engineering Experiment Station's investigation is the solution of a two-fold problem: (1) extraction of the fiber from flax straw at low cost, and (2) utilizing it successfully on cotton machinery. This work has been carried on by the Chemical and Textile Engineering Divisions of the Station at the Georgia School of Technology. A processing method that in a sense is a reversal of the established European procedure has been followed—"green" fiber being first extracted from the straw by mechanical scutching or decortication, and then subjected to chemical retting or degumming to prepare it for spinning. This method was adopted in the belief that it might offer a cheaper and more satisfactory way of processing than the European procedure of water retting followed by scutching, which is expensive, laborious and disagreeable. Approximately ten tons of fiber flax and seed flax, grown in Georgia and Oregon during the past two years, has been processed to date.

The purpose of decortication is to separate the principal elements of the flax plant from each other; that is, seed, fiber and woody core or shive. Many patents have been issued on mechanical decortication machines but few successful ones seem to have been built for preparing textile fiber. As the amount of green fiber in a flax plant represents only 15 to 20 per cent of its overall weight and the seed about the same, a machine must deseed and decorticate straw at low labor and power cost. At the same time, it must produce a fiber clean of shive, the woody core material that makes up about 50 per cent of the weight of the flax plant and is at present a waste material. Two experimental machines have been on trial at the Engineering Experiment Station during the past six months that seem to meet these requirements and are

suited to small scale commercial operation. The straw first passes through a number of coarse, fluted rolls which remove the seed bolls and give the straw a preliminary breaking that loosens the fiber from the woody core. It then goes through a series of reciprocating, slotted knives that impart a rubbing action which cleans out the shive, and the fiber is discharged in hanks of long fibrous ribbons. These machines require only two operators and little power, and could be set up in a small plant, like a cotton gin, near the flax fields. This is an important consideration from the standpoint of production costs, as the bulk of the flax plant is shive, primarily a waste material and uneconomical to transport.

The straw must be well dried before decortication in order to obtain clean fiber. Best results seem to be obtained when the moisture content of the straw is in the range of from 3 to 5 per cent. Flax is very hygroscopic and artificial means of drying would have to be provided in most regions in connection with the decortication equipment. Our experience at the Station indicates that the straw could be economically handled and conditioned in a large storage space equipped with unit heaters to heat and circulate air at the moderate temperatures and low humidities required.

The problem in degumming is to remove the shive still clinging to the decorticated fibrous ribbons or bundles of fiber, and enough of the gums to allow separation of these bundles into nearly the ultimate fibers of flax, so that they can be handled on cotton machinery. We have studied the action of many chemicals, but find that only a few have an appreciable effect. The method of treatment we have adopted involves an alkaline hydrolysis with a mild reducing action to prevent oxidation of the cellulose fibers. It is carried on in a pressure vessel, with outside means of heating and circulating the liquor, at temperatures around 330° F. for two to three hours. The product comes out in silky, white hanks of finely divided but long fibers which are then thoroughly washed and dried.

It is too early yet for us to say what the costs of decortication and degumming would be on a commercial scale. Our present experimental procedure naturally involves considerable hand work, much of which can be mechanized into continuous systems, thereby speeding up production and reducing costs. The reclamation and reuse of the degumming chemicals appears feasible and should considerably reduce the cost of the operation. It may be that the success of this method of processing flax will depend very largely on the credits which can be obtained from the reclamation of the chemicals and the profitable utilization of by-products, especially the shive and seed.

Spinning degummed fiber also presents problems. Cotton machinery is built to handle a fine, soft fiber that is fairly uniform in length and diameter. Degummed or "cottonized" flax does not have the softness or uniformity of cotton, nor does it have cotton's characteristic spirality which gives the latter such good spinning qualities. The flax fiber is straight, smooth and rather stiff. Consequently it is doubtful whether an all flax yarn can be spun on the cotton system that is as even and as strong as a cotton yarn.

Our present procedure of preparing the degummed fiber for spinning involves some mechanical pretreatment. The hanks are cut into the desired staple lengths and then passed through a waste opener and a picker. This action breaks the fiber bundles down into a soft, fluffy mass that can be handled by regular cotton equipment with minor modifications. As might be expected, the waste losses are greater than in spinning cotton, and the yarns are less uniform and strong. With the improved degummed fiber that seems on the way, and the use of certain modified equipment, we believe, however, that usable 100 per cent flax yarns of average counts may be produced.

Of more immediate interest is the fact that small admixtures of cotton to the degummed flax considerably improves its spinnability and the uniformity, strength and fineness of the yarns produced. This is important because of the trend toward mixed or blended fiber fabrics for certain classes of goods. If we can demonstrate practicability, quality and economy in fabrics made of American flax mixed with cotton or rayon, there will be a substantial market for them. The most likely outlets are in toweling, summer suitings and dress goods, draperies and upholstery, table cloths and the like. We have produced a number of these fabrics already, and feel that certain of the desirable characteristics of each fiber are imparted to the cloth. Little difficulty has been experienced in dyeing the yarns or in bleaching the fabric when the flax has been properly degummed.

For several years now, a number of cotton textile mills have been blending imported flax with cotton and rayon. The flax has ranged in quality from stapled linen fiber—similar to our degummed fiber—to noils that are much cheaper but dirty, full of shive and lacking in uniformity. The mills tell us that they would use domestic degummed or "cottonized" fiber if it could be obtained in comparable quality, at about the same price, and from an ample and steady source of supply.

And so we face the old laws of supply and demand, price and competitive products, which have killed many another promising development. We are keeping these hard facts always before us, but they are stimulants rather than deterrents. If flax is not feasible for southern agriculture and industry, at least the reasons should be defined and published. Our findings may save the expenditure of many thousands of dollars in the future by others. It appears to us now however that further investigation on a broad scale may establish domestic flax on a commercial basis.

Those engaged in this project are: C. A. Jones, Project Director; C. G. Worthington, T.V.A. Research Fellow; Harold Bunger, R. L. Hill, J. L. Taylor, W. L.

CARMICHAEL, J. R. BRANDON, L. M. THOMPSON, L. R AHERN, C. P. GOODYEAR, H. G. ADAMS, H. M. VERDERY and RANDOLPH REYNOLDS.

DISCUSSION

President Eavenson: You mentioned the progress of the industry might depend on the recovery of the chemicals, but if you mentioned the amount of chemicals required, I failed to catch it. What chemicals are used in the removing of this material?

Mr. Worthington: We have tried a number of chemicals but the alkalies seem to be the best ones.

President Eavenson: Caustic soda?

Mr. Worthington: Caustic soda has been partly successful.

President Eavenson: But that has to be fairly strong?

Mr. Worthington: Yes, sir, at present. This degumming problem is a big one, and we have quite a way to go on it yet. It may be that a combination of chemicals will do best and there are indications pointing that way at present.

Determination of Sulfur in

Surface-Active Agents*

RALPH HART**

ONE of the best criteria of the quality of any detergent or wetting-out agent of the sulfuric acid ester or sulfonic acid type is the content of organically combined sulfuric anhydride. The methods available for this determination are (*a*) the Herbig method[6] in which the sample is decomposed with hydrochloric acid and the sulfate is determined in the water layer after extracting the fat with ether; in another sample, the inorganic sulfate is determined by washing the oil layer, dissolved in solvents, with concentrated sodium chloride solution and determining the alkali sulfate in the wash waters. (*b*) The Herbig method has been mostly superseded by the acid-titration method[4], in which the sample is decomposed with a known quantity of sulfuric acid and the organically combined sulfuric anyhdride is calculated from the increase in acidity. (*c*) The last and most recent method is the ash-gravimetric method[5], which has been adopted as provisional by the American Association of Textile Chemists and Colorists[1], the American Oil Chemists' Society[2], and the American Society for Testing Materials[3]. According to this method the pure sulfonated product is first isolated by extracting with solvents over a concentrated solution of salt and then ashed; from the weight of the ash the combined sulfuric anhydride may be calculated.

The first two methods evidently cannot be used in the case of true sulfonates, which are not decomposed by acids under the conditions of the methods. Furthermore, in the case of highly sulfated sulfuric acid esters, these methods are inconvenient, as it takes a long time for complete hydrolysis—sometimes over 10 hours. The ash or third method may be used for sulfonated as well as sulfated products and is satisfactory for the ordinary type of sulfated oils. Unfortunately in the case of highly sulfated oils or the newer sulfonated detergents, such as the sulfated alcohols, sulfonated fatty acid amides, etc. (particularly if it is necessary to use alcohol as one of the solvents in extraction), the extract carries over with it in solution a large amount of salt, which vitiates the results. Every effort to remove the salt from the solvent by filtering, freezing, or dehydrating has been unsuccessful.

The method proposed in this paper is applicable to every type of sulfated or sulfonated organic compound, provided it may be quantitatively extract with a solvent over concentrated salt solutions. This was true of every such compound investigated that possessed detergency or surface activity. The sodium salt of β-naphthalenesulfonic acid could not be analyzed by this method, since it was soluble in the salt solution and could not be extracted with solvents, but this compound has no value as a detergent and probably very little value, if any, as a wetting-out agent. The new method is convenient and comparatively rapid, and the results are of good precision and accuracy. It is based upon the observation that the sodium or potassium salt of the sulfonated or sulfated product when shaken with a concentrated solution of ammonium chloride or sulfate is quantitatively converted into its ammonium salt and, conversely, the latter is converted into the sodium or potassium salt when shaken with a concentrated solution of the respective chloride or sulfate.

PROCEDURE

Shake the sample, dissolved in the proper solvent or solvents, repeatedly with a concentrated solution of am-

*Industrial & Engineering Chemistry.
**The Hart Products Corp.

monium chloride until the conversion is complete—about five portions. Wash the solvent layer similarly with a concentrated solution of sodium sulfate; all the ammonia bound to the organically combined sulfate or sulfonate is quantitatively converted into ammonium sulfate, which passes into the water layer. The latter also contains all the ammonium chloride with which the solvent layer may have been contaminated. The water layer is now analyzed for total ammonia by distillation with excess alkali and for ammonia due to ammonium chloride by analyzing the same solution or an aliquot portion of it for chloride, an analysis which is most conveniently determined volumetrically. The difference represents the ammonia bound by the organic compound; from these data the organically combined sulfuric anhydride may readily be calculated. A duplicate analysis may be made within 3 hours, regardless of the complexity of the sample.

SALT WASHINGS. To a mixture of 50 ml. of a concentrated neutral solution of ammonium chloride (about 30 per cent containing some solid salt) and 50 ml. of ether in a 250-ml. separatory funnel, add enough of the sample to yield about 0.5 gram of organically combined sulfur trioxide and shake vigorously until the sample is completely dissolved. If the sample is a solid, it may more conveniently first be dissolved in water, to which the proper amount of ammonium chloride is then added. Add 5 drops of methyl orange indicator and sufficient 0.5 *N* hydrochloric acid until the water layer after settling is faintly pink. Draw off the lower layer and repeat the washing with four 25-ml. portions of the ammonium chloride solution or until conversion into the organic ammonium salt is complete, shaking vigorously each time for about 1 minute. With unknown samples, a duplicate analysis is made and when the ash of the oil layer upon ignition is negligible, complete conversion has taken place. If an emulsion forms during the washings, add 3 ml. of alcohol at a time, mixing gently after each addition, until the emulsion breaks comparatively rapidly and forms two clear, sharp layers. With certain highly sulfonated oils, three layers may form; in that case, either add enough alcohol to cause the middle layer to combine with the ether layer or draw off only the lower water layer. Combine the washes and extract with one or more portions of 25 ml. of ethyl ether (or with equal parts of alcohol and ether where three layers are formed); discard the water layer and wash the solvent layer with two 10-ml. portions of the ammonium chloride solution. Combine the solvent layers and similarly wash with a neutral 25 per cent solution of sodium sulfate (about 35° C.) free from chlorides and containing some solid salt—or until all of the ammonia is transferred to the water layer. (To test for complete conversion at this stage, the wash water is tested for ammonia in the usual way.) Combine the sodium sulfate washes, extract once with 25 ml. of ethyl ether, and wash the latter with two 10-ml. portions of the sulfate solutions which are combined with the other washes. Total ammonia and ammonia as chloride are determined in the combined sodium sulfate washes, as follows:

TOTAL AMMONIA. Dilute the sulfate washes exactly to 500 ml. and determine the ammonia by distilling an aliquot portion or 200 ml. in a Kjeldahl flask with about 35 ml. of *N* sodium hydroxide solution, absorbing the liberated ammonia in 25 ml. of *N* sulfuric acid, and determining the loss of acidity of the latter with 0.5 *N* sodium hydroxide solution, using methyl orange as the indicator. To prevent foaming, pumice stone and 20 to 30 ml. of octyl alcohol may be added to the solution before distillation. Total ammonia is given by the following formula, expressed as milligrams of potassium hydroxide:

$$\text{Total ammonia, as mg. of KOH} = \frac{1}{a}(\text{ml. of } H_2SO_4 \times t_1 - \text{ml. of NaOH} \times t_2)$$

where t_1 and t_2 represent the titers of the acid and alkali, respectively, in milligrams of potassium hydroxide per ml., and a is the fraction of the solution taken for analysis.

AMMONIA AS CHLORIDE. To another 200-ml. portion of the solution, add 0.1 *N* or 0.25 *N* silver nitrate solution, depending upon whether the extract is more or less contaminated with ammonium chloride (if alcohol was used in the extraction, considerable amounts of ammonium chloride will usually be present), until present in some excess (about 5 ml. of 0.1 *N*), stir continually for about 10 minutes or until the precipitate has coagulated well, filter, and wash the filter free from silver nitrate. Add 2 ml. of nitric acid (4 parts of strong nitric acid and 1 part of water, boiled until colorless), 5 ml. of ferric ammonium chloride (saturated solution), and titrate with 0.1 *N* ammonium thiocyanate solution to a definite brown. Standardize the silver nitrate solution against standardized hydrochloric acid, following as closely as possible the actual test—namely, in the presence of about 200 ml. of a 10 per cent solution of sodium sulfate. The ammonia bound as chloride is calculated as follows:

$$\text{Ammonia bound as chloride, in mg. of KOH} = \frac{1}{a}(\text{ml. of } AgNO_3 - \text{ml. of } (NH_4)SCN \times E)t_3$$

where E represents the equivalent of the thiocyanate in terms of the silver nitrate (standardized in a 10 per cent sodium sulfate solution) and t_3 equals the titer of the silver nitrate, expressed in milligrams of potassium hydroxide.

TABLE I

Sulfuric Anhydride in Sulfated Products

Product	*Organically Combined SO_3 — Ammonia or New Method* I %	II %	Av. %	*Acid-Volumetric Method* I %	II %	Av. %
Sulfated oleic acid	3.88	3.85	3.87	3.90	3.98	3.94
Sulfated castor oil	3.92	3.98	3.95	4.26	4.22	4.24
Sulfated tallow	2.53	2.48	2.51	2.54	2.60	2.57
Sulfated blended oil*	3.42	3.51	3.47	3.54	3.61	3.58
Highly sulfated castor oil..	6.68	6.58	6.63	6.92	7.04	6.98
Sulfated fatty alcohol	6.13	6.24	6.19	6.01	6.16	6.09

*Used in spinning rayon.

ORGANICALLY COMBINED SULFURIC ANHYDRIDE. It is evident, from the formulas for the ammonium salts of sulfuric acid esters and sulfonic acids ($ROSO_3NH_4$ and RSO_3NH_4), that one mole of ammonia is equivalent to one mole of combined sulfuric anhydride. Hence, the organically combined sulfuric anhydride is readily calculated from the previous data as follows (the ammonia results are given in milligrams of potassium hydroxide):

$$\text{Organically combined } SO_3\text{, as ester or sulfonic acid, per cent} = \frac{(\text{total ammonia}) - (\text{ammonia as chloride})}{\text{weight of sample}} \times \frac{SO_3}{10\ KOH} =$$

$$0.1426 \left[\frac{(\text{total ammonia}) - (\text{ammonia as chloride})}{\text{weight of the sample}}\right]$$

EXPERIMENTAL

COMPLETE CONVERSION INTO AMMONIUM ORGANIC SALTS. To prove that the conversion into the ammonium organic salts was quantitative, sulfated and sulfonated products, including samples of sulfated oleic acid, castor oil, fatty alcohol, sulfonated fatty acid amides, and sulfonated mineral oil, all in the form of their sodium salts, were washed as outlined in the method and a portion of the ether layers was ashed. The ash in each case was negligible.

COMPLETE CONVERSION INTO SODIUM SALT. The rest of the ether layers were then washed with sodium sulfate solution and tested for ammonia by distillation with excess alkali. The results were all negative.

EXTRACTION. Extraction in each case was quantitative, as shown by the fact that the wash waters after prolonged boiling with strong acid and further treatment with ether gave either negative results or only traces of fatty matter.

STABILITY OF SULFONATED OIL IN SOLVENT LAYER. To determine the stability of products of the sulfuric acid ester type (which have a tendency to decompose under neutral or acid conditions) during washing with the salt solutions, samples of a sulfated castor oil, sulfated oleic acid, and a sulfated fatty alcohol were washed as in the procedure and allowed to remain overnight at room temperature. The ether layers upon further washing showed no development of acidity and there was no decrease in the combined sulfuric anhydride.

DETERMINATION OF AMMONIA AS CHLORIDE. No difficulty was caused in this determination by the presence of sodium sulfate. The method was tested by neutralizing known amounts of hydrochloric acid in the presence of sodium sulfate and determining the chlorine content.

SULFURIC ANHYDRIDE CONTENT IN SULFURIC ACID ESTERS

The organically combined sulfuric anhydride in commercial samples of sulfuric esters, including a sulfated fatty alcohol, was determined by the new method and compared with the volumetric acid-decomposition method. The results are given in Table I. There is a satisfactory agreement between the two methods in the case of the sulfated oleic acid and the sulfated alcohol, but with sulfated castor oil and other glycerides the new method yields results that are 0.1 to 0.4 per cent lower. The higher results by the acid-volumetric method were probably due to sulfated glycerol, which apparently is not extracted by the new method. This conclusion was based upon the following experiment: A sample of sulfated castor oil was extracted over a salt solution and the combined sulfuric anhydride determined according to the acid-volumetric method. The result then agreed with that obtained by the ammonia method.

TABLE II
Sulfuric Anhydride in Sulfonic Compounds

	Organically Combined SO_3				
	Purified Sample		*Sample "As Is,"*		
	Ammonia or new method	*Ash method*	*Ammonia or New Method*		
Product	av. %	av. %	I %	II %	Av. %
Fatty acid amide sodium sulfonate	15.9	15.8	4.39	4.38	4.37
Alkyl naphthalene sodium sulfonate	24.2	24.4	15.9	16.1	16.0
Alkyl aryl sodium sulfonate	22.6	22.6	7.87	7.80	7.84
Sulfonated mineral oil	11.7	11.9	11.4	11.9	11.7

SULFURIC ANHYDRIDE CONTENT OF SULFONIC COMPOUNDS

In the case of sulfonic compounds, the samples were extracted with ether and alcohol over a concentrated solution of sodium chloride, the solvent was evaporated, and the residue was dried. The residue was then digested in a small quantity of hot alcohol and filtered to free it from salt. The solvent was evaporated and the residue dried to constant weight. The sample of sulfonated mineral oil was analyzed directly, since it was completely soluble in ethyl ether. Part of the purified residue was analyzed for sulfuric anhydride by the new method. Another portion was ashed, treated with 2 ml. of concentrated sulfuric acid, and ignited to constant weight and the sulfate in the residue, determined by precipitation with barium chloride, was compared with that by the ammonia method. The sulfate determined by the ash method represents half of the sulfuric anhydride, in accordance with the following reaction that takes place upon ashing:

$$2RSO_3Na \rightarrow Na_2SO_4 + SO_2 + CO_2$$

Some of the sodium sulfate is reduced to sulfite and sulfide, but these do not interfere with the results, if the ash is finally treated with sulfuric acid. The results obtained with several sulfonic compounds are given in Table II.

SUMMARY

A new, convenient, and accurate method has been developed for the determination of sulfuric anhydride in sulfuric acid esters and sulfonic compounds. The method is based upon the conversion of the respective compounds into their ammonium salts and determining the ammonia in the latter.

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The Determination of the

Dry Weight of Cotton

by Means of the Commercial Ventilated Drying Oven*

M. STEPHENSON, B.Sc., A. Inst. P.**

INTRODUCTION AND SUMMARY

THE same procedure for the determination of the dry weight of cotton by drying in the commercial ventilated oven is now generally adopted everywhere but certain differences occasionally exist. It was recently brought to the notice of the staff at the Shirley Institute that in at least one laboratory the dry weight was determined by transferring the dried sample to a container and then weighing on an external balance. The weights so obtained were on the average considerably lower than if the dried cotton had been weighed in the oven.

Variations in the results obtained by different methods of oven drying textile materials have long been noted. These variations have had such an important bearing upon the comparative results of different laboratories and different investigators that an active interest has recently developed in the study of this phase of textile laboratory work. With this in mind we are reprinting from *The Journal of the Textile Institute* this paper which appears to be an important contribution to this study.

L. A. O.

Investigations have been carried out at the Institute to determine which of the results is the more correct, and at the same time to analyze errors that may exist in dry weight determinations in normal commercial drying ovens. The conclusion reached is that the differences are principally due to the introduction of errors when the samples are weighed on the external balance so that the oven method is the more accurate. It should, however, be made clear that while the conclusions concerned with weighing in the oven are probably general for the normal type of oven, this is not necessarily so, for the magnitude of the relevant factors may vary from oven to oven.

The results of the investigations are now published in the general interest, and are summarized as follows.

(1) Usual Method of Dry Weight Determination.

It appears that errors in the usual method, i.e., weighing in the oven, would, in general, for samples from 100 gm. to 500 gm., result in the observed value of the weight of the dried sample differing by no more than 0.1 per cent from the correct weight, the observed weight being almost always the lower of the two.

Davidson and Shorter[1] have discussed the definiteness of the dry weight of cotton as determined under the usual conditions in a commercial oven. Their results indicate that if grey cotton is dried at 107° C., the permanent loss of material other than hygroscopic water is approximately 0.07 per cent, and also that drying at this temperature by no means removes all the hygroscopic water. If the partial pressure of the water vapor in the atmosphere is 10 mm. of mercury, the residual regain is approximately 0.15 per cent.† Hence the correct weight of the sample when dried under these conditions is roughly 0.08 per cent above the "true dry weight," which is defined as the constant weight obtained by prolonged exposure at room temperature to the dry atmosphere produced by phosphorus pentoxide. With bleached cotton the "permanent loss" is negligible; the difference between the correct weight of the sample (dried in a similar manner) and the true dry weight is +0.15 per cent.

Hence, if the observed weight of the dry sample (dried under these conditions) differs from the correct weight by amounts between 0.00 per cent and —0.1 per cent, it will agree with the true dry weight to 0.1 per cent. It is, however, possible that in certain atmospheres the residual regain might be so large as to result in appreciable error.

(2) The "External Balance" Method.

Errors in the "external balance" method have been found to be as much as 0.4 per cent regain on 500-gm. samples. For smaller samples the errors are frequently bigger (i.e., 0.6 per cent regain on 250-gm. samples). Almost always the values obtained for the dry weight are too low, and hence for the regain are too high.

These errors in the external balance method are apparently due, principally, to two causes; (*a*) absorption of moisture by the sample during transference from oven to container; and (*b*) an effect due to the warm air enclosed with the cotton. The weight of a "container-full" of this warm air is less than the weight of the air at room temperature enclosed in the container when the "empty"

*Journal of the Textile Institute.
**British Cotton Industry Research Association.

†See Fig. 2 of Davidson and Shorter's Paper.

weight is being determined, even when the pressure of the enclosed air is the same in each case. If the container is hermetically sealed the difference between the weights of the enclosed air in the two cases may be accentuated.

Error (*a*) tends to make the measured dry weight too high and (*b*) tends to make it too low. In general, (*b*) is much more important than (*a*), but in any test the actual net error will depend on the particular circumstances, e.g., the time taken to transfer the sample to the container, the time elapsing before the completion of weighing (if the container is not hermetically sealed), the atmospheric humidity and temperature, the weight of the sample, and the volume of the container.

In the "external balance" method of dry weight determination (*a*) is always present but is very variable in magnitude. If the container is not hermetically sealed, error (*b*) may be eliminated by waiting till the contents have cooled down to atmospheric temperature and the density of the air enclosed has risen to that of the surrounding air, but the amount of moisture diffusing into the cotton during this period must of course be negligible. In general, the more rapid the transference of the sample from the oven to the container, the smaller error (*a*) will be and the larger (*b*), for if the cotton is rapidly transferred it has not cooled so much on reaching the container and the air enclosed is of a lower density. If error (*b*) is eliminated the value for the regain of the sample will be too low, depending on (*a*). The result will only be correct in the fortuitous combination of circumstances when errors (*a*) and (*b*) are equal (and opposite).

ANALYSIS OF THE SOURCES OF ERROR

The sources of error and the magnitude of each error, expressed as a percentage of the dry weight, are derived from theory in this section, which is followed by a record of actual experiments with a commercial drying oven.

(1) Weighing in the Oven.

(*a*) *Errors directly due to changes in density of air as a result of temperature changes.*—The oven consists essentially of an upright jacketed cylinder, through which a current of air, preheated by electric heating coils, can be blown by means of an electric fan. The cotton to be dried is contained inside the cylinder in an open-work metal basket, suspended from the arm of a balance capable of weighing 1 kg. to the nearest 0.02 gm. The temperature of the hot air is maintained constant to within 1° C.

When the heater and draught are switched off the air enclosed with the cotton cools more slowly than the surrounding air. Hence, owing to the fact that the density of air increases as its temperature decreases (pressure remaining constant) a "balloon effect" is produced, tending to make the recorded weight too low. At the same time the cotton is being weighed in less dense air than when its moist weight was determined. This tends to make the recorded weight too high. These two sources of error are best considered together.*

Let M_1, v_1 and M_2, v_2 be respectively the masses and volumes of the moist and dried cotton.

Let V be the volume of the dried sample plus enclosed air.

Let p_1 be the mean density of the atmosphere in which the weighing of the moist sample is carried out.

Let p_2 be the mean density of the air in the oven surrounding the sample.

Let p_3 be the mean density of the enclosed air.

Observed moist weight $= M_1 - p_1 v_1$.

Observed dry weight $= M_2 + p_3(V - v_2) - p_2 V$ (neglecting effects of convection currents).

Observed difference $= (M_1 - M_2) + (p_2 - p_3)V - (p_1 - p_3)v_1$.

(The difference between v_1 and v_2 is neglected.)

(1) *The "balloon effect."* The recorded value of the dry weight would be $[(p_2 - p_3)V/M_2] \times 100$ per cent too low relative to the moist weight, if this were the only error. With a value of 25 c.c. per gm. for V/M_2 (e.g., 500 gm. of cotton occupying 12½ liters), and on the assumption that the temperatures of the enclosed and surrounding air are, respectively, 107 and 100° C., $[(p_2 - p_3)V/M_2] \times 100$ per cent $= 0.04$ per cent approx.

The temperature difference between the center of the cotton and the surrounding air has not been found to exceed 7° C. before the completion of a weighing, but the value of V/M_2 may in certain cases be greater than 25 c.c. per gm. and hence the error due to the "balloon" effect may possibly exceed 0.04 per cent.

(2) *The effect of the difference in temperature at weighing.* If the moist and dry weights are measured at temperatures differing by 90° C., the error $(p_1 - p_3)v_1$ tends to make the recorded value of the dry weight about 0.02 per cent too high.

In most cases the net result of effects (1) and (2) is an error probably not exceeding 0.02 per cent.

(*b*) *Convection currents.*—The effect of convection currents has been found to be not so great as might be expected. For normal samples and ovens, and the usual weighing procedure, the error may be 0.05 per cent (too light). For most purposes such errors may be neglected, but it should be noted that if the error is appreciably increased, as it may easily be with particular ovens and samples, it will then be serious and correction will be difficult. For example, if the flue carrying away the hot air is high and the passage of that air is unobstructed, comparatively strong convection currents may arise. These would very considerably affect the apparent weight of a light sample which had been well fluffed out in a large basket. The cure for such errors apparently lies in the

*The differences between the densities of the air enclosed with the moist sample in its container and of the external air due to humidity differences are very small. The resulting errors would seldom exceed 0.01 per cent of the weight of the sample.

design of drying ovens; they should be well jacketed and constructed so that through air currents are at once reduced to a very low value on switching off the draught of hot air.

(*c*) *Absorption of moisture by dried cotton during weighing.*—This error (i.e., increase in residual regain) is very small. During the time required to weigh the sample its temperature does not fall by more than 2 or 3° C. The work of Davidson and Shorter[1] has shown that such a fall in temperature would at most result in a change in equilibrium residual regain of about 0.03 per cent. Equilibrium will not be reached except possibly with very small open samples.

The net result of all these errors is that the observed dry weight as determined by weighing in the oven may be as much as 0.1 per cent less than the correct dry weight.

(2) Weighing in a Container on an External Balance.

(*d*) *Moisture absorbed on transferring the cotton from the oven to the container.* This error is variable but may be serious, of the order of 0.2 per cent of the dry weight (too heavy) if the transference of the cotton occupies half a minute and the atmospheric R.H. is approximately 50 per cent.

(*e*) *Effect of warm air enclosed with the cotton.*—Warm air enclosed with the cotton has a low density, causing a "balloon effect" error. If the container is hermetically sealed the error is, in practice,* more serious than if it leaks slightly, for if it leaks, as the cotton and air slowly cool, air passes into the container to equalize the pressure inside and outside. In any case, since cotton is a bad conductor of heat, the outside of he container may feel cool while the inside is say 50° C. above room temperature. The error may be analyzed as follows:—

Let M_1, v_1 and M_2, v_2 be respectively the masses and volumes of the moist and dried cotton.

Let m be the mass of the container.

Let V be the volume of the container.

Let p_2 be the mean density of the enclosed air during weighing.

Let p_1 be the mean density of the air surrounding the container and also of the air in which the moist weight was determined. (If these two densities differ appreciably another small error is introduced.)

Then, neglecting the effect of convection currents and moisture absorbed by the cotton before the completion of the weighings,

(*a*) Recorded weight of container + contents $= M_2 + p_2(V - v_2) - p_1V + m$.

(*b*) Recorded weight of container $= p_1V - p_1V + m$.

(*c*) Difference between (*a*) and (*b*) $= M_2 - p_2v_2 - (p_1 - p_2)V$.

(*d*) Recorded weight of moist sample $= M_1 - p_1v_1$. The difference between (*c*) and (*d*) $= M_1 - M_2 + (p_1 - p_2)(V - v_1)$ since v_1 and v_2 are very approximately equal.

If the difference between the mean temperature of the contents of the container and the temperature of the surrounding air is 50° C., and if the volume of the container is 10 liters, the observed dry weight will be approximately 2 gm. too light.

The actual error may vary widely in different cases, being larger for smaller samples in large containers. For a 250-gm. sample in a 10-liter container, an error of 0.6 per cent of the dry weight, too light, has been observed.

(*f*) *Convection currents.*—The errors are very small since the container itself cools rapidly. They are negligible in comparison with errors (*d*) and (*e*).

(*g*) *Moisture diffusing into the container from outside.*—This error is quite negligible for a good container.

Hence the weight obtained from the external balance readings is approximately:—

True dry weight, plus *the weight of water absorbed during transference,* and minus *the difference between weights of a "container-full" of room-temperature air and the "container-full" of warm air.*

The net error may be expected to vary from 0.2 per cent of the dry weight) too heavy, to 0.5 per cent (of the dry weight) too light. In particular cases even larger errors may occur.

EXPERIMENTS

Data forming the basis of the above discussion were provided by experiments designed to measure the magnitudes of the various effects. The essentials of the experiments are as follows.

(1) Investigation of Effects of Air Currents on Weighings Made in the Oven.

Sheet aluminium baskets having fairly large surface areas (450 sq. cm.) in a horizontal plane (i.e., perpendicular to the air stream), weighing approximately 85 gm., and sorbing negligible amounts of water vapor, were weighed in the oven under several conditions. The results recorded in Table I show that the apparent weight varied only slightly, even though the shape of the objects was such that convection currents might have been expected to have relatively important effects.

(2) Effect of Density of Air in Container. (Non-hygroscopic Materials).

A large tin, holding 9.3 liters and not hermetically sealed, was filled with odd metal to increase its heat capacity and maintain a farily high temperature inside while being weighed, and to have an invariable "regain." The tin and contents were weighed cold in the oven, then heated for 100 minutes at 105-110° C. and weighed again. The whole was then transferred to an external balance and

*If a hot body is placed in a contained initially containing cold air, and the container is immediately hermetically sealed, it is possible that the internal pressure may in a short while exceed the external pressure. The "balloon effect" may then be small, but it will always be present. When weighing dried cotton, the conditions are such that before the container can be sealed the air inside is on the average quite warm and the "balloon effect" is appreciable.

TABLE I

	Difference from initial "cold" weight (gm.)	
	First basket	*Second basket*
Weighed cold (before experiments)	0 ± .01	0 ± .01
Oven heater and fan full on	—0.87 to —0.96	—0.9
Immediately after switching heater and fan off	—0.12 to +0.02 (mean —0.04)	—0.05 to +0.02 (mean —0.02)
Ten minutes after switching off	—.01 to +.02 (mean 0.00)	—0.03 to +0.03 (mean 0.00)
Weighed cold after several hours	0.00 ± .01	—0.02 ± .01

TABLE II

Conditions of weighing	*Apparent weight of tin and contents (gm.)*	*Temperature of contents of tin (°C.)*	*Temperature of air surrounding tin (°C.)*	*Weight calculated from initial weight when cold and difference in air temperatures* (gm.)*
Weighed cold in oven	1337.87±0.1	20	20	1337.87±0.1
In oven just after fan and heater were switched off	1337.47±0.1	100	96 falling to 83	1337.48±0.1
On external balance	1336.30±0.01	65	22	1336.39±0.1
On external balance	1337.20±0.01	46	22	1336.99±0.1
On external balance	1337.50±0.01	35.5	22	1337.37±0.1
On external balance	1337.85±0.01	24	22	1337.79±0.1

*Balloon effect correction = $(p_2 - p_3)V$ (see earlier; Convection neglected.

TABLE III

Time after switching off heater and fan (mins.)	*Final weight minus apparent weight (gm.)*	*Temperature* (1) *Contents of container (°C.)*	*Temperature* (2) *Air surrounding container (°C.)*	*"Balloon effect" correction † (gm.)*	*Difference attributed chiefly to convection currents (gm.)*	*Error on a 400 gm. sample ‡ (%)*
(Initial "cold" weight = final "cold" weight = 1219.78 gm.						
1½	0.36	99	92	0.18	0.18	—0.09
*5	0.31	95	88	0.18	0.13	—0.08
10	0.32	91	83	0.21	0.11	—0.08
16	0.27	84	78	0.17	0.10	—0.07
55	0.14	60	58	0.06	0.08	—0.04
*59	0.09	59	56	0.09	0.00	—0.02
61	0.10	58	56	0.06	0.04	—0.03

*Indicates that for these weighings the oven flue was closed.
†"Balloon effect" correction = $(p_2 - p_3)V$ (see earlier).
‡"Balloon effect" and convection current errors. For cotton, the error due to the difference in temperature at weighing, and the resultant of permanent loss and residual regain, algebraically increase the net error and may even make it positive.

weighed at intervals. Just after each weighing the inside temperature was recorded. (In measuring these and all other temperatures, due precautions have been taken to ensure that the recorded temperatures were not falsified by any possible effect due to the thermal capacity of the instrument employed to measure the temperature.) The results are in Table II.

From the good agreement between the observed and calculated weights it appears that the chief cause of the weight variation is the change of density with temperature of the enclosed air. Convection currents apparently play a negligible part.

(3) Effect of Convection Currents and Density of Air on Weighings Made in the Oven.

A large unsealed metal container, the volume (10 liters) of which was of the same order as that of a 400- or 500-gram sample, was filled with smaller canisters also unsealed, and arrangements were provided so that the temperature inside it could be observed. The whole was intended to simulate a cotton sample in a basket as

regards size, shape, thermal capacity, and the partial immobilization of the air contained, without, however, showing appreciable changes in moisture content. It was hung in the oven as if it were a normal sample and heated for 70 minutes at approximately 105° C. The heater and draught of air were switched off and the container with contents weighed *in situ* at intervals with the results given in Table III.

(4) Cooling of Cotton in the Oven and Surrounding Air after Switching Off the Heater and Fan.

The results of two tests are given. In each, 400 gm. of cotton was heated for more than 2 hours at 105 to 110° C. The fan and heater were then switched off and the temperature of the air round the cotton gradually fell. After a few minutes the temperature of the center of the cotton was found to have changed very little. Readings of thermometers were made at (1) the top and (2) the bottom of the oven drying chamber, and (3) and (4) at two points well in the cotton. (See Table IV.)

TABLE IV

Time after switching off fan and heater (mins.)	*Temperatures (°C.)*			
	Air		*Cotton (center)*	
	Top (1)	(2)	(3)	(4)
0	93.5	107		
1	89.5	104		
3	84.5	96	110	109
0	96.5	108.5		
2	89.5	101		
4	85.5	92		
10	79.5	75.5		
11			107.5	104

The gross volume of the cotton and enclosed air was approximately 10 liters. The normal time for completion of a weighing is no more than 2 minutes. Hence, even if the air temperature falls 7° C. more than does the temperature of the center of the cotton in that time, then:—

Error due to density (on 400 gm. of cotton)

$$= \frac{10 \times 273 \times 7 \times 1.29}{373 \times 380} \text{ gm.}$$

i.e., 0.17 gm.

The slowness of the cooling of the cotton indicates that the center of the cotton (and air) in a container may be quite warm while the container itself is cold.

(5) Examples of "Dry Weight" Determination by Weighing in a Container on an External Balance.

The dry weight of approximately 470 gm. of cotton was determined by drying and weighing in the oven. The sample was then transferred fairly rapidly (in approximately 30 seconds) to a container (capacity 9.6 liters) fitted with a thermometer, and weighed at intervals on an external balance. The results are in Table V.

TABLE V

Time in hours after removal from oven	*Difference between temperature of center of cotton and room temperature*	*Apparent weight of contents (gm.)*
0.12	approx. 70° C.	431.22
0.17	66° C.	431.40
0.30	64° C.	431.65
0.42	59° C.	431.84
0.92	33° C.	432.28
2.2	7° C.	432.69
4.4	1½° C.	432.77
22.5	0° C.	432.83
Dry weight obtained by weighing the cotton in the oven		431.90

The container employed was sufficiently leaky to enable the internal air pressure to equal the external pressure, but the fact that over the last 18 hours (i.e., after the contents had almost cooled down) the weight only increased by 0.06 gm. (0.014 per cent) showed that diffusion of moisture into the container was inappreciable.

It has been established that the weighings in the oven are not in error (in this case) by more than about —0.07 per cent ("balloon" effect, etc., —0.02 per cent; convection —0.05 per cent). Hence the difference of +0.93 gm., between the final weight of the contents (432.83 gm.) and the weight in the oven (431.90 gm.) must be very largely due to the weight of water absorbed during transference from the oven to the container. A similar test (Table VI) showed the same salient features.

TABLE VI

	"Dry weight" of cotton
(1) Weighed in oven (normal procedure)	500.2 gm.
(2) Transferred to a container (in approximately 1 minute) and then weighed on external balance	499.70 gm.
(3) Weighed on external balance after some hours on attainment of almost steady weight	501.26 gm.
Volume of air in container = 9.3 liters.	

The difference of 1.06 gm. between (1) and (3) is, as before, largely ascribed to the absorption of moisture during transfer to the container. It may be noted that in this particular case the error due to moisture absorption during transfer has nearly corrected for the error due to the decrease in the density of the enclosed air.

Reference

[1]Davidson, G. F., and Shorter, S. A. *Shirley Institute Memoirs*, 1929, *8*, 197-210; or *J. Text. Inst.*, 1930, *21*, T165-178.

Recent Research

and its Bearing on Wool Piece Goods Dyeing*

H. T. JACKSON

THE whole subject of the successful dyeing of wool piece goods is one that has, from time to time received much attention, but never more than during recent years, in which investigations of very considerable interest have been carried out. We refer particularly to the work of Mr. F. L. Goodall and Professor F. M. Rowe, which was described before the Society of Dyers and Colourists some little time ago. It is encouraging to find that scientific workers are going so thoroughly into the subject, and it is conceivable that others will be given an incentive to examine still further aspects of the matter. There can be few other branches of the art of dyeing that have given rise to the acute controversies which have attended discussions on the dyeing of woolen or worsted piece goods. After all, the dyeing of piece goods is so very final; so little can be done to cover defects and while in many other forms of textile materials levelness is extremely important, we prefer, for the purpose of this article, at any rate, to treat the levelness of wool piece goods as of absolutely paramount importance.

The appearance of scientific contributions on the fundamental structure and properties of the wool fiber, as illustrated, for example, by the work of Speakman, Astbury and others, are inevitably all leading towards permanent solutions to problems that have beset the piece dyer from time immemorial. It is true that many of the problems—listing and draughting to mention only two—that have been the bogy of the piece dyer since the very beginning, have, for the time being, at any rate, been overcome by careful observation and experience. But it cannot, unfortunately, be claimed that they have been overcome permanently, nor, indeed, can they be until the causes that underlie the faults have been ascertained beyond all possible doubt.

DIFFERENCES OF OPINION ON LISTING

One finds on all sides strong opinions as to the reasons for listing, for example. Some dyers claim that it is essentially a weaving fault, due to curling lists, for instance. Others maintain equally strongly that the fault is due to the preparatory processes, such as scouring. Still other dyers maintain that dyes that are satisfactory in some districts are just as unsatisfactory in others; in other words, most dyers are on the edge of a volcano which might, at any moment, erupt upon them. Admittedly, one must take account of varying conditions, the water supply being the one that springs first to one's mind. Nevertheless, when the time comes, as undoubtedly it will, that all the aspects of listing are clearly tabulated and proved, the dyer will, in the great majority of cases, be able to take his precautions and thereby ensure satisfaction. The point we wish to stress is that work of a purely theoretical character in respect of dyes, assistants, fibers and processes cannot be too strongly encouraged if the dyer is to be really freed from this anxiety and uncertainty.

It might, of course, be argued that once all these faults are clearly understood, the craftsmanship of wool piece dyeing will largely disappear, but whether this is so or not, we venture to suggest that there is no piece dyer in existence who would not eagerly welcome a permanent solution of this particular problem. There still remains, after all, the art of dyeing all the different qualities to produce the requisite finishes, and even with modern colorimeters and other physical measuring devices, the day is still far distant when a shade can be matched automatically without the aid of the skilled dyer.

At the same time, one cannot ignore the possibility of an era of finely controlled conditions that might permit the treatment of piece goods, from the point of view of finish, in a purely mechanical way, but we feel that this particular problem is probably the most distant from solution of all the problems of the piece dyer, since it is almost impossible to conceive a state of automatic control that could cater satisfactorily for all the differing qualities, weights and so on, with which the piece dyer is daily called upon to deal. Automatic shade matching is not, perhaps, quite so far away, especially with the accurate colorimeters that are available. That (given standard readings of the recognized colors employed) it might eventually be possible to take the necessary readings that would determine (theoretically, at any rate) the exact additions required to produce a given shade, is a possibility no progressive dyer can afford to ignore, and it may be, as time goes on, that instruments of this kind will be used more and more by dyers of all kinds of textile materials. One hesitates to dwell too long on a conjecture of this kind, but it must be remembered that, given a sufficient urge, the solution of most problems is inevitable eventually and color matching is certainly one that has given rise to a great deal of thought for very many years. It is not, indeed, wise to sit back and feel that the physical instruments evolved are not still perfect, or that conditions of dyeing are so variable that absolute standardization is impossible to attain. It is, of course, true that instruments are not always equally accurate throughout the range of the spectrum, and that they are liable to become fatigued, thus making the ac-

*The Dyer and Textile Printer.

curate reproduction of all shades a matter of some considerable difficulty at the present time.

One might also argue that no two dyes are absolutely alike in respect of their affinity for wool or in their solubilities; but, on the other hand, dyestuffs chemistry is advancing, and the discovery of new dyes and assistants is being made almost daily. One can, in fact, foresee the possibility of standardized conditions being attained, even to the control of temperatures of the dye bath to within quite close limits. Thermostatic control has not, it is true, been altogether satisfactory in the past, but more robust and reliable instruments are being made available, so that we are, at any rate, within sight of the almost absolute control of one of the most variable of all dyeing factors.

We cannot leave the subject of future possibilities without referring to the paper by Professor Rowe and his colleagues before the Society of Dyers and Colourists in February, 1938. We see, for example, that Professor Rowe and Dr. Speakman, "had collaborated in directing investigations of the chemical and physical changes experienced by wool dyers on exposures to light and air, and the bearing of these changes on the difficulty of realizing level dyeings with loose wool and worn garments." That such an investigation must eventually have a bearing on wool piece dyeing is quite evident when the fundamentals of the investigation are fully realized. Except in certain cases, such as draughting, for example, the wool piece dyer may not be concerned with actual exposure to light and air, or at any rate for sufficient time for some of these changes to take place, but it might well be that some of the explanations will be found to fit in with some of the well recognized faults that are peculiar to the dyeing of wool piece goods.

BREAKDOWN OF CYSTINE LINKAGES

The dyer, judging the question from a practical point of view, might perhaps argue that the "breakdown of the cystine linkages," of the wool fiber is far removed from piece dyeing, but a little reflection will show that it is not really so very far more removed after all. For example, the authors of this paper point out that their investigations have shown that the cystine linkages under the action of light and air lead to the loss of surface scales and permit increased swelling of the damaged fibers. They conclude, and probably quite rightly, that what can happen with single staples can happen similarly with worn garments. It is, therefore, not a very far step from the worn garment to the actual fabric itself, and in which a similar kind of fiber damage may be caused by processing faults.

LIGHTER AND DARKER DYEINGS

It is mentioned, for example, that fibers exposed in this way dye more deeply with colloidal dyes, of which the neutral dyeing acid colors are examples, while the crystalloidal dyes, represented by the level dyeing class of acid colors, dye the exposed fibers a lighter hue than the unexposed portions. It is conceivable that the listing effects that are, from time to time, obtained with colloidal dyes, such as the Coomassie Navy Blues or Sulfoncyanines, may be explained and corrected by the explanations and recommendations which these workers have put forward. As darker lists are generally obtained, if listing is being experienced, with colors of this type, the similarity is certainly interesting, and although other factors may play their part (greasy and soapy residues, for example), it would be of considerable interest, if listing is prevalent, to try giving a few pieces the pretreatment in acid solution of particular basic chromium acetates, as suggested by the authors of the paper. In this connection we cannot do better than quote from the extract of the paper published in *The Dyer* of March 11, 1938, p. 227. The extract reads: "The chromium acetate minimized the excessive reducing power of exposed wool by combining with the sulfydryl groups, thus preventing the development of different hues on exposed and unexposed wools when acid dyeings were afterchromed. In addition, it formed new linkages between the peptide chains of the wool in place of those linkages which had been broken by exposure, thus minimizing the excessive swelling properties of exposed wool. The chromium acetate pretreatment process thus promoted level acid dyeings and diminished the need for using aggregating or auxiliary products in the dyebath. Such pretreatment was permissible even with wool which was to be dyed with acid dyes because the wool was not mordanted by the treatment." It is perhaps early to attempt to visualize completely the ultimate effect of the work that formed the basis of this valuable paper, but one can foresee the possibilities of extending the usefulness of the work to the realms of wool piece dyeing, and for explaining and correcting some of the faults that are inherent to this particular branch of wool dyeing.

THE WORK OF GOODALL

We have already referred to the recent work on the subject of wool dyeing by Goodall, whose paper on the subject appeared in the *J.S.D.C.*, Feb., 1938, 54, No. 2, pp. 45-46. Many readers will, no doubt, already have studied the paper in detail, and will agree that as a practical contribution to the study of all forms of wool dyeing its value cannot be over-estimated. As, however, we are only concerned here with piece dyeing, it will be sufficient to discuss the paper briefly from that point of view. The number of examples provided on pages 60-63 on the subject of piece dyeing show, if any evidence were needed, that the author had the question of piece dyeing well in mind, and while one must admit to some degree of astonishment at the suggestion of actually entering pieces at the boil, and with unlevel dyeing colors into the bargain, one cannot but be impressed at the results that have been achieved. An experiment that appeals with particular force is that in which four pieces of indigo serge were dyed to a navy shade with 2.5 per cent Erio

Fast Blue S5R and 1 per cent Cloth Fast Blue SGG. The additions given were 1 per cent ammonium sulfate and 0.5 per cent sodium bichromate. The pieces were worked for ten minutes, raised to boiling point in twenty minutes, and after boiling for an hour the pieces were found to be "very satisfactory," even though the dyebath exhausted rather rapidly. Other examples of chrome and acid dyestuffs applied in a similar manner are given and, in the author's words, "This alkalinity, whether actual or only effective in the sense of reduced acidity, is required in order to reduce the *initial* rate of sorption only, and is, therefore, itself only required in the early stages of a high temperature dyeing. In practical terms, therefore, the proposed method resolves itself into entering at the boil into a dyebath containing no Glauber's salt or other aggregating compound, with the same amounts of acid as would be used in a normal low temperature dyeing, partially or entirely neutralized with ammonia."

HOW FUNDAMENTAL RESEARCH CAN HELP

We have referred to these two recent contributions not only because of their practical significance to the wool piece dyer, but also because they show how fundamental work, on the one hand, on the wool fiber itself and on the other on the dyestuffs side, can not only explain the occurrence of certain faults but also provide means of overcoming them. Let us hope that more and more workers will extend the investigations so admirably begun and thereby lessen the anxieties that the piece dyer has had to face for such a very long time. There must be a host of significant observations that have been made by practical dyers that could be turned to excellent account if only they could be investigated by academic or other workers who have the time and knowledge necessary for their complete elucidation.

It should be recognized that nothing but good could come from a more whole-hearted collaboration between the practical men and those who are more concerned with the theoretical side of the question. Each has so much to give to the other that it seems such a pity that more combined efforts of this kind cannot be made. While the practical man can learn by experience and sometimes by trial and error, he never can have the time, nor, perhaps, to some extent, the kind of training, that would permit of a logical and clearly proved explanation of any particular problem. It must be remembered, too, that if a scientific worker is to reach results of ultimate practical importance, he must, in the first place, be given the problem by the practical man, who can, by a careful definition of the matter, make doubly certain that the work to be carried out is absolutely on the correct lines. It is so easy for the scientific worker to launch forth on some entirely theoretical problem or to branch out on to aspects that, although interesting in themselves, are of limited practical importance, that guidance by the practical man is unquestionably essential. Fortunately, there are already signs that this collaboration between the two sides is taking place more and more, and there can be little doubt that the results that already have been obtained are only a forerunner of discoveries of even greater importance.

Profitable Research

A Communication

J. E. BULLARD

THE present standard of living in the United States, the fact that there are no more unemployed than there are, the ability of this country to provide for the very poor in the comparatively luxurious manner it does, can be credited primarily to scientific and industrial research. To forestall objections to the statement that our poor are provided for luxuriously, however, it may be well to state that the poorest people in the United States, today, actually enjoy a higher standard of living than the average wage earner of a few centuries ago did, when he was employed full time.

Most people had the experience during the World War of buying black cotton stockings which left the legs and feet black. The explanation was that the war had cut off the supply of German dyes and American dyes were not as good. The German dyes were good for the simple reason that, after the war of 1870, Germany began scientific and industrial research in a big and serious way. The Reichsanstalt was established in Berlin. Technical colleges were established in a number of centers. When the Englishman, Perkins, founded the modern dye industry, it was to Germany he had to go for support. There, he found a better realization of the practical value of research than he did in his own country.

Germany led in dye research work up to the end of the war. It was her research laboratories, more than any other one thing, which enabled her to fight as long as she did. But, just as the war of 1870 started Germany on the road which led in the direction of gaining a monopoly of dyes and dyestuffs, so the World War awoke this

nation to the need of more research in the chemical field. The result has been the building up of our present great chemical and dye industries. Today, it is claimed that American dyes are the equal of, if not much superior to, dyes which can be made in any other part of the world. It has all been due to research. It has created jobs in the research laboratories and also in the plants making the dyes.

To a marked degree it has been due to the far-seeing industrial leaders that research has been carried on to the degree it has been in the United States. By 1927 it was estimated that no less than 16,000 scientists and engineers were engaged in this country in research on behalf of the industries and that around 110 million dollars were being spent for the work each year.

It is the work these men are doing which has led manufacturing practices in all industries to progress vastly more during the past 25 years than in any previous period of even a greater duration. That is why so many new industries have prospered, so many products can be made here at less cost than in other countries where much lower wages are paid to labor but not as much research is conducted.

Even the small manufacturer finds research work pays him. I talked with the manufacturer of special marking machines. He makes machines for marking any sort of material. He told me that, at no time during the depression, had he laid off a single employe. Not only had he not reduced his working force but he was opening a new branch. His business was growing.

After telling me that, he took me into a little chemical laboratory next his office. It was this laboratory, he said, that kept his business prosperous. The standard marking machines he had been selling for years would not have supplied a fraction of the employment this laboratory helped him to give steadily.

He was searching for new uses for marking machines, for problems which had not been solved. In a great many cases, the ink, the dye needed was an important problem. In this laboratory he spent most of his time finding the particular combination of chemicals which would meet each and every requirement of a given marking job. Most anybody could have built the machines. It required a laboratory in which to discover the actual marking material best suited to each specific case.

This firm is not a large one. It does not employ many people. It did succeed in making a profit during years when a great many other firms, both large and small, were losing money. It was able to keep every employe on the payroll. It was a real asset to the city in which it is located. It was that because of the profits which emanated from that little research laboratory, from the work done by one man who is getting on into years.

What this firm is doing indicates there is no company too small to find a certain amount of research work profitable. There is usually some department in which it is needed. If there is no research it becomes almost, if not quite, impossible to meet competition.

There are some who go so far as to insist that the right combination of scientific, industrial and marketing research will prevent business depressions from visiting us at periodic intervals. It is said, by these people, that had there been sufficient industrial research during the late twenties, there would have been no such depression as we have experienced since 1929. They point out that the automobile industry made the quickest recovery and that this was due primarily to the research work which made it possible to produce a better car at a lower price. So much more was given to the buyer for the money he spent that he could not resist the temptation to buy. The new cars were so much better than the old ones that a year old car looked old fashioned and completely out of style besides not being nearly as easy to drive or as comfortable to ride in.

Of one thing we may be certain. It was research and research in many fields, from that of the dyes which color the upholstery to the alloys which go into the gear box, from the processing research all the way from the raw material to the finished car which made the automotive industry, in 40 years, major industry of this country. There were only four gasoline driven motor cars in the United States in 1896.

The future of the textile industry, in this nation, depends more upon research than upon any other one thing. This research must not be confined entirely to chemistry, to dyes. It must cover all fields. One which is closely allied to dyes is accurate color measurement, a codification of colors so colors may be accurately matched. There has been such a standardization in steel alloys. When a piece of steel or a casting, forging or sheet is ordered by an S.A.E. number, one knows it will conform to other orders which have been placed for the same S.A.E. number. All that is needed, in the way of additional information, is the kind of heat treatment which is to be given it. These S.A.E. numbers are the standardized results of research.

There must be more industrial research all along the way. Merchants selling textiles have a way of complaining that people are not buying so much now, that they are spending more money for automobiles. They point out that the clothes present-day women wear are only a fraction of the amount their grandmothers wore. In fact, they wear so little that when the sun is shining in the summer you may be able to look right through the clothes they have on.

There may be some truth in the statement that people are spending so much money for automobiles they do not have enough left to buy all the clothes they should wear. If there is truth, it is due to the fact that the automobile industry has spent more money in research than the textile and dye industries have.

One of the most amazing facts, of the present day, is

the degree to which people are able to reduce their expenditures for absolute necessities, in order to have more to spend for things which their ancestors of only a few generations ago had never heard. People have actually cut down on their food, cut down on their clothing, lived in cheaper homes in order to own automobiles.

This means that every worker in a dye or textile laboratory is creating jobs for workers in mills and factories in the industry. Every research worker who is laid off not only loses his own job but sooner or later there will be more and more wage earners unemployed in the industry due to the lack of the information, the knowledge this worker would have gained and which would have been applied to the industry.

It not only is profitable to do research work, it is suicidal not to increase the number of research workers and to add to the money spent in this direction. Competition is no longer merely between individual firms in the same industry. The most serious competition is between industries. The laundry industry is a much better industry since the laundryowners got together for research work. As a matter of fact, they really had to get together to remain in business. Research in the textile industry was producing new dyes, new materials such as rayon, new mixtures. These presented laundering problems. They could be solved only through research.

The dye and the textile industries are probably the oldest ones we have. We know that textiles were dyed several thousands of years before the Christian era. Up to within the past fifty years, however, the addition to the knowledge already acquired was little, century by century. As research has become more intense, there has been a speeding up in progress. Future profits, most certainly, depend upon present research.

CALENDAR OF COMING EVENTS

Meeting, Society of Chemical Industry, Chemists' Club, New York, N. Y., February 10, 1939, at 7:45 P. M. Members of the A.A.T.C.C. are invited. Dinner at 6:30 P. M.; make dinner reservations with Steward of Chemists' Club. Speaker: Dr. Wanda K. Farr, Boyce Thompson Institute; Subject: "Viscose Rayon."

Meeting, Piedmont Section, The Poinsett, Greenville, S. C., February 11, 1939.

Meeting, Mid-West Section, Bismarck Hotel, Chicago, Ill., February 18, 1939. Dinner at 7:00 P. M. Program: Election of Officers; movie: "Wings of the Morning" by Railway Express Agency.

Meeting, Southeastern Section, Hotel Ralston, Columbus, Ga., February 18, 1939, dinner at 7:00 P. M. Election of officers, reports of officers, report on Annual Meeting, etc. One speaker will be William M. McLaurine, secretary-treasurer of the American Cotton Manufacturers Association, who will speak on present conditions and prospects in the southern textile industry.

Annual Meeting, Inter-Society Color Council, Auditorium of the Electrical and Gas Association of New York, 480 Lexington Ave., New York, N. Y., February 23, 1939. Members of the A.A.T.C.C. are invited. The program follows:

9:30 A.M.—Business Session.

2:00 P.M.—Technical Session on Color Tolerances. The Physics of Color Tolerance—Deane B. Judd; The Psychophysics of Tolerances — Edwin G. Boring; The Ratio Method in the Review of the Munsell Colors—Sidney M. Newhall; Color Tolerances as Affected by Changes in Composition and Intensity of Illumination and Reflectance of Background — Harry Helson; Representation of Color Tolerances on the Chromaticity Diagram—David L. MacAdam; Specification of Color Tolerances at the National Bureau of Standards—Deane B. Judd; Industrial Color Tolerances—Isay Balinkin.

8:00 P.M.—Popular Session: Parade of Color. Color in Medicine—E. N. Gathercoal; Color in Paper—J. L. Parsons; Color in Textiles—W. D. Appel; Color in Industry—H. Ledyard Towle; Color in Lighting—R. G. Slauer; Color in Psychology—M. J. Zigler; Color in Fashion—Elizabeth Burris-Meyer.

NOTE: Admission to the evening session is by ticket only; they are available without cost upon application to the secretary, Dorothy Nickerson, c/o Bureau of Agricultural Economics, Washington, D. C. Send stamped, self-addressed envelope.

Meeting, New York Section, Swiss Chalet, Rochelle Park, N. J., February 24, 1939, 8 P. M. Dinner at 6:30 P. M. Speaker: John H. Faunce, American Rolling Mills; Subject: "Stainless Steel as Applied to the Dyeing and Finishing Industry."

Meeting, Philadelphia Section, Penn A. C., Philadelphia, Pa., March 3, 1939.